A Dissertation on

"ASSESSMENT OF FUNCTIONAL OUTCOME OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLE HAMSTRING AUTOGRAFT"

Dissertation Submitted to

THE TAMIL NADU Dr.M.G.R. MEDICAL UNIVERSITY

CHENNAI- 600032

with partial fulfillment of the regulations

for the award of the degree of

M.S (ORTHOPAEDICS)

(BRANCH I1)

COIMBATORE MEDICAL COLLEGE

COIMBATORE

MAY 2018

CERTIFICATE

This is to certify that this dissertation entitled "**ASSESSMENT OF FUNCTIONAL OUTCOME OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLE HAMSTRING AUTOGRAFT**" is the bonafide research work done by **Dr.MOHAN PRASAD.M** and submitted in partial fulfillment of the requirement of the degree of Master of Surgery in Orthopaedics, Coimbatore Medical College and Hospital, Coimbatore.

DATE:

Prof . Dr.P.KOSALARAMAN
M.S.Otho, D.Ortho,
ASSOCIATE PROFESSOR & THESIS GUIDE

DATE:

Prof Dr. S.VetrivelChezian
M.S.Otho, D.Ortho, FRCS(Glasgow), PhD
PROFESSOR & HOD
DEPARTMENT OF ORTHOPAEDICS

DATE:

Prof B. Asokan M.S. MCh (Plastic)
DEAN
COIMBATORE MEDICAL COLLEGE
COIMBATORE – 641014

CERTIFICATE – II

This is to certify that this dissertation work titled "**ASSESSMENT OF FUNCTIONAL OUTCOME OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLE HAMSTRING AUTOGRAFT**" of the candidate **DR.MOHAN PRASAD.M** with registration Number **221512251** for the award of **M.S Degree in Orthopedics.** I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains 104 pages from introduction to conclusion and the result shows 1**% (One)** percentage of plagiarism in the dissertation.

Guide & Supervisor sign with Seal.

ACKNOWLEDGMENT

I wish to express my sincere thanks to our respected **Dean Prof. B. Asokan M.S. Mch (Plastic surgery)** for allowing me to conduct this study in our hospital.

I express my heartfelt thanks and deep gratitude to the head of department of Orthopaedics **Prof Dr. S. Vetrivel Chezian M.S.Ortho, D.Ortho, FRCS (Glasgow), PhD** for the generous help and guidance in the course of the study.

I would like to express my gratitude to my guide **Dr. P. Kosalaraman M.S. Ortho, D.Ortho.,** without whose help and advice this work would not have been possible.

I owe a great debt of gratitude to our Associate professor **Dr. D.R.Ramprasath** for his constant guidance and encouragement throughout the period of my study.

I sincerely thank all my assistant professors **Dr.K.S.Maheswaran, Dr.S.Marimuthu, Dr. M.S.Mugundhan, Dr.P.Balamurugan, Dr. K. Gajendran, Dr. R. Vivekanandhan** for their valuable help and suggestions during my study.

I would like to express my gratefulness for the staff nurses and multipurpose workers for their assistance and helpfulness. Last but not least I express my gratitude to all patients who cooperated in this study

DECLARATION

I, **Dr. MOHAN PRASAD.M**, solemnly declare that the dissertation titled "**ASSESSMENT OF FUNCTIONAL OUTCOME OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLE HAMSTRING AUTOGRAFT**", was done by me at Coimbatore Medical College during the academic year June 2015 – September 2017 under the guidance of **Prof. Dr.P.KOSALARAMAN M.S.Ortho, D.Ortho,** This is submitted to "The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the regulations for the award of M S degree branch II Orthopaedics.

Dr. MOHAN PRASAD.M

Post graduate in M.S.Orthopaedics

Coimbatore Medical College

COIMBATORE, TAMILNADU, INDIA - 641 014

(Affiliated to The Tamilnadu Dr. MGR Medical University, Chennai)

ETHICS COMMITTEE

CERTIFICATE

Name of the Candidate : DR. MOHAN PRASAD . M

Course : POST GRADUATE IN MS [ORTHOPAEDICS]

Period of Study : ONE YEAR

College : COIMBATORE MEDICAL COLLEGE AND HOSPITAL

Dissertation Topic : ASSESSMENT OF FUNCTIONAL OUTCOME OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLE HAMSTRING AUTOGRAFT

The Ethics Committee, Coimbatore Medical College has decided to inform that your Dissertation Proposal is accepted / ~~Not accepted~~ and you are permitted / ~~Not permitted~~ to proceed with the above Study.

23/04/2016

Member Secretary
Ethics Committee

URKUND

Urkund Analysis Result

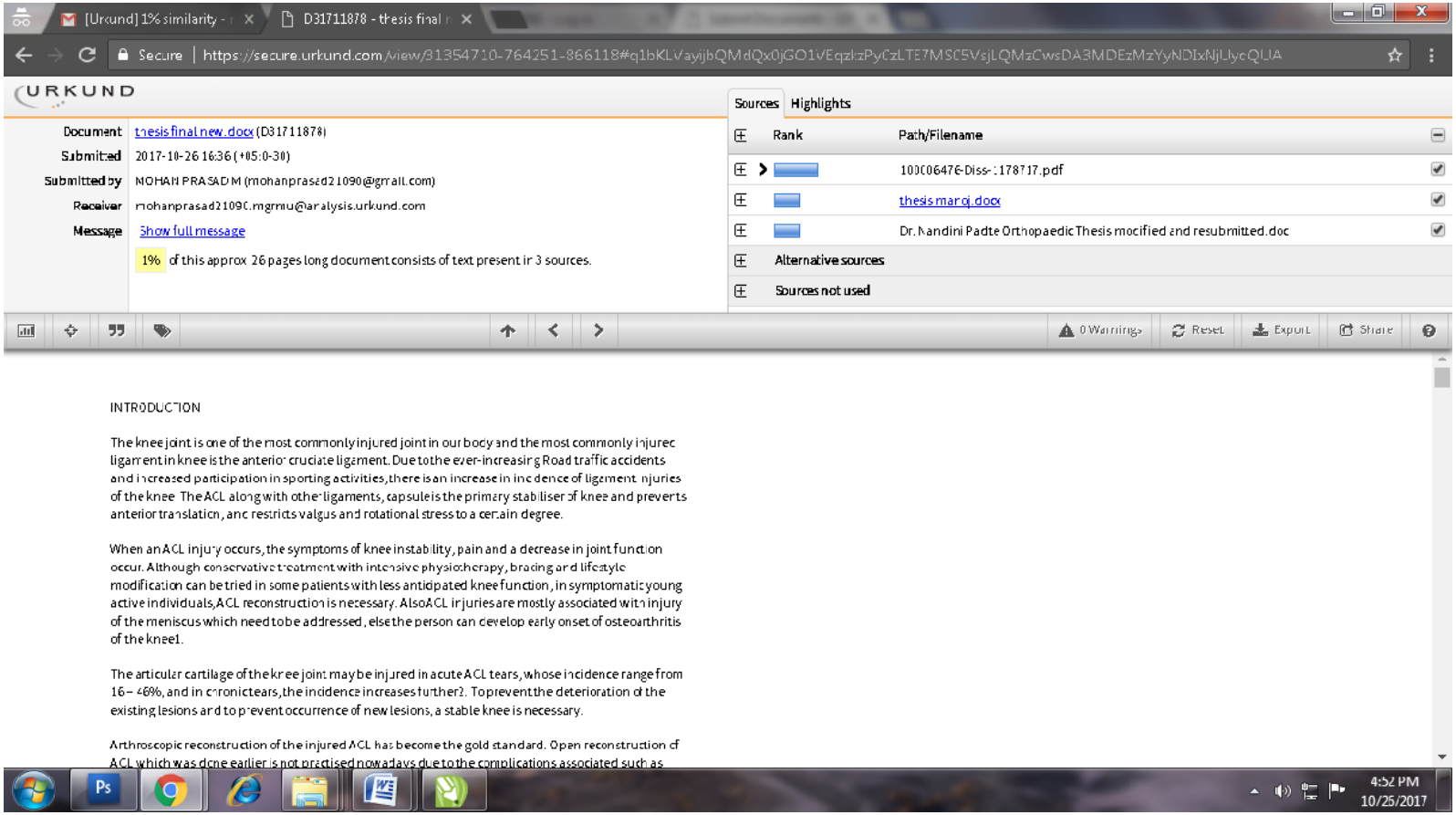
Analysed Document: thesis final new.docx (D31711878)
Submitted: 10/26/2017 1:06:00 PM
Submitted By: mohanprasad21090@gmail.com
Significance: 1 %

Sources included in the report:

thesis manoj.docx (D31183858)
100006476-Diss-1178717.pdf (D17854333)
Dr. Nandini Padte Orthopaedic Thesis modified and resubmitted.doc (D22636371)

Instances where selected sources appear:

4



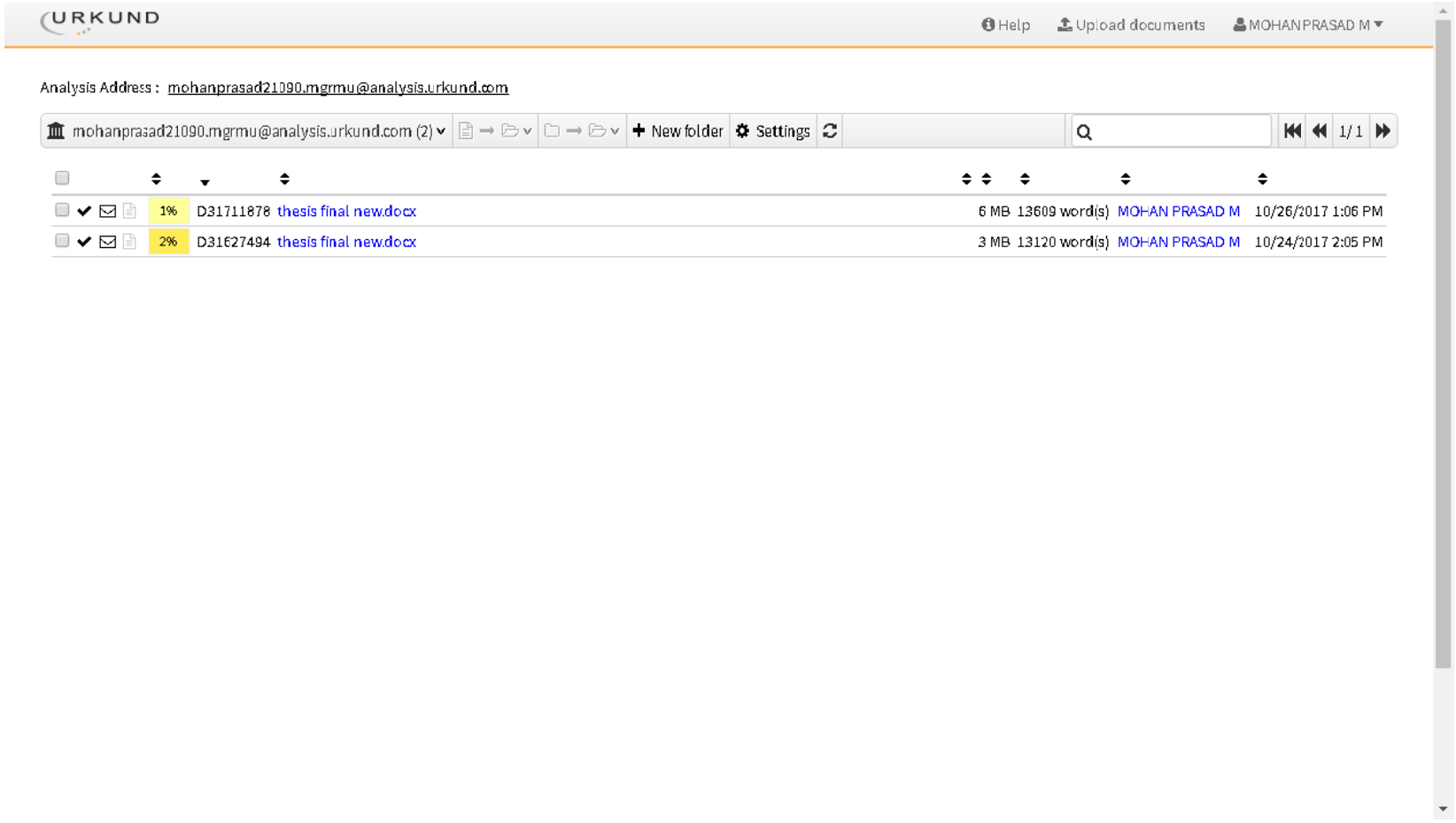
INTRODUCTION

The knee joint is one of the most commonly injured joint in our body and the most commonly injurec ligament in knee is the anterior cruciate ligament. Due to the ever-increasing Road traffic accidents and increased participation in sporting activities, there is an increase in incidence of ligament injuries of the knee. The ACL along with other ligaments, capsule is the primary stabiliser of knee and prevents anterior translation, and restricts valgus and rotational stress to a certain degree.

When an ACL injury occurs, the symptoms of knee instability, pain and a decrease in joint function occur. Although conservative treatment with intensive physiotherapy, bracing and lifestyle modification can be tried in some patients with less anticipated knee function, in symptomatic young active individuals, ACL reconstruction is necessary. Also ACL injuries are mostly associated with injury of the meniscus which need to be addressed, else the person can develop early onset of osteoarthritis of the knee1.

The articular cartilage of the knee joint may be injured in acute ACL tears, whose incidence range from 16 – 46%, and in chronic tears, the incidence increases further2. To prevent the deterioration of the existing lesions and to prevent occurrence of new lesions, a stable knee is necessary.

Arthroscopic reconstruction of the injured ACL has become the gold standard. Open reconstruction of ACL which was done earlier is not practised nowadays due to the complications associated such as


URKUND
Help
Upload documents
MOHAN PRASAD M
Analysis Address : mohanprasad21090.mgrmu@analysis.urkund.com
mohanprasad21090.mgrmu@analysis.urkund.com (2)
New folder
Settings
1/ 1
1% D31711878 thesis final new.docx 6 MB 13609 word(s) MOHAN PRASAD M 10/26/2017 1:06 PM
2% D31627494 thesis final new.docx 3 MB 13120 word(s) MOHAN PRASAD M 10/24/2017 2:05 PM

CONTENTS

SL.NO	CONTENTS	Page No
1	Introduction	1
2	Aims and Objectives	3
3	Review of literature	4
4	Materials and Methods	52
5	Results	85
6	Cases illustration	96
7	Discussion	107
8	Conclusion	115
9	Bibliography	116
10	Annexures	
	I.IKDC Score	129
	II.Lysholm Knee Score	131
	III.Proforma	132
	IV.Consent Form	137
	V.Master Chart	138

INTRODUCTION

The knee joint is one of the most commonly injured joint in our body and the most commonly injured ligament in knee is the anterior cruciate ligament. Due to the ever-increasing Road traffic accidents and increased participation in sporting activities, there is an increase in incidence of ligament injuries of the knee. The ACL along with other ligaments, capsule is the primary stabiliser of knee and prevents anterior translation, and restricts valgus and rotational stress to a certain degree.

When an ACL injury occurs, the symptoms of knee instability, pain and a decrease in joint function occur. Although conservative treatment with intensive physiotherapy, bracing and lifestyle modification can be tried in some patients with less anticipated knee function, in symptomatic young active individuals, ACL reconstruction is necessary. Also ACL injuries are mostly associated with injury of the meniscus which need to be addressed, else the person can develop early onset of osteoarthritis of the knee[1].

The articular cartilage of the knee joint may be injured in acute ACL tears, whose incidence range from 16 – 46%, and in chronic tears, the incidence increases further[2]. To prevent the deterioration of the

existing lesions and to prevent occurrence of new lesions, a stable knee is necessary.

Arthroscopic reconstruction of the injured ACL has become the gold standard. Open reconstruction of ACL which was done earlier is not practised nowadays due to the complications associated such as increased post op pain, stiffness and a lengthy rehabilitation phase.

The “ideal graft” for ACL reconstruction is still a topic of debate. The most commonly used grafts are bone patellar tendon bone graft and hamstring graft. Several studies have demonstrated comparable functional outcomes for both the grafts.

The hamstring graft is increasingly used nowadays for the following reasons.

- Advancements made in soft tissue graft fixation techniques
- Increased incidence of anterior knee pain with bone patellar tendon bone graft

AIM

To evaluate the functional outcome of arthroscopic single bundle anterior cruciate ligament reconstruction using quadrupled hamstring tendon (Gracilis and semitendinosus) autograft in individuals with ACL injuries.

REVIEW OF LITERATURE

The first description of the true nature of ACL that it is a joint stabiliser, which restricts abnormal motion, was given by Galen[3] (Circa 170 AD)

In 1845, Amedee Bonnet[4] described three signs which are suggestive of ligament injury. They included snapping noise, haemarthrosis and loss of function of the knee.

James Stark[5], a general practitioner from Edinburgh (1811–1890), observed two cases of cruciate ligament tears in 1839 and 1841, respectively, describing some of the typical signs of ligament rupture ‘‘… and felt somethinggave way with a snap in the left knee; when raised, she found she had lost all command over the leg.’’ Stark is often quoted as the first clinician to describe cases of ACL deficiency in the English literature.

George K Noulis[6] wrote a thesis on “Knee Sprains” in 1875. In that, he gave an accurate description of the ACL and he stated that the integrity of the ligament should be assessed in knee extension.

Paul F. Segond[7], published a study titled “Clinical and experimental research into bloody effusions of the knee joint in sprains” in 1879. In the study, he found that avulsion fracture of the anterolateral

margin of tibial plateau was commonly associated with ACL tears. The fracture is named after him which is now considered as pathognomonic of ACL tears.

The first ACL repair was done by A.W. Mayo Robson in 1895[8].

The first ACL reconstruction was done using an iliotibial transplant in 1917 by Ernest W. Hey Groves[9].

The use of tibial based medial third patellar tendon graft was first described by William C. Campbell in 1935[10].

The use of semitendinosus tendon for ACL reconstruction was first described by Harry B. Macey in 1939[11].

The first use of central third of patellar tendon with bone block was done by Kenneth G. Jones in 1963[12].

D.L McIntosh did extra-articular reconstruction using fascia lata in 1972[13].

The Lachman test was described by Joseph S. Torg, student of John Lachman[14] in 1976.

The first prosthetic ACL made of Dacron was developed by Rubin, Marshall and Wary in 1975[15].

ACL reconstruction using free bone patellar tendon bone graft was first done by Clancy.

In 1982, the first use of semotendinosus and gracilis for ACL reconstruction was done by Lipscom[16].

In 1984, Nayes et al[17] stated that bone patellar tendon bone graft was the strongest having 160% strength of the normal ACL whereas semitendinosus had 70% , graciluis 49% of normal ACL strength.

The arthroscopic reconstruction of ACL using four strand hamstring graft was first done by M.J.Fredman in 1988[18].

The fixation with endobutton was first devised by Tom Rosenberg, fixation using polyethylene anchor by L.Paulos[19] and biodegradable interference screw by A.Staehelin[20].

In 1992, Beynnon et al.[21], in their study, showed the use of knee braces for six months after ACL reconstruction to protect the grafts.

The use of KT 1000 arthrometer was first described by Bach et al.[22] in 1990 to test the knees with ACL injury. He recommended its use in diagnosis and follow up of ACL injured patients.

Ray et al.[23], in their study done in 1988, compared the functional outcome of surgical and conservative treatment in ACL tears. They found that 50 % had excellent or good results and 50 % fair result or failure in conservative treatment group whereas in surgical group, all patients except two had excellent or good results.

Cyril B. Frank et al.[24], in their study, concluded that the functional outcome of arthroscopic ACL reconstruction was better compared to open repair in short term but in long term follow up, the results were similar.

But **Hamid Barzegar et al**.[25], in their study comparing arthroscopic assisted and open surgery in ACL repair concluded that arthroscopic assisted reconstruction is superior to open surgery.

In another comparative study by **Cameron et al**.[26], they found that there was no significant difference between arthroscopic and open repair with respect to anterior drawer test, but the post op range of movements was statistically significant favouring arthroscopic repair.

The number of studies comparing open repair and arthroscopic assisted repair are few as arthroscopic reconstruction is a minimally invasive and cosmetic surgery and has overshadowed open repair.

The most commonly used grafts for ACL reconstruction are the bone patellar tendon bone graft and hamstring graft.

Spindler et al.[27], did a systemic review of randomized, controlled studies which compared patellar tendon and hamstring autografts. They found that pain with kneeling was greater in the patellar tendon group in all four studies in which it was analysed and increased anterior knee pain in one study. There was no significant difference in graft failure between the two groups.

Yunes et al. in their study found that better stability was achieved with the use of bone patellar tendon bone graft but such grafts are associated with higher prevalence of patellofemoral pain

Michael Wagner et. al.[28], in their study found that the hamstring graft was superior in knee stability and function, thus recommending hamstring graft even in high level athletes.

Irrespective of the type of graft used, fixation of the graft is usually the site of failure rather than the graft itself. This usually occurs during early rehabilitation phase as the graft integration has not occurred during this time. The fixation is of less significance after two to three months as the graft would have integrated with the bone. (Dann T Culick)

Usually the ACL reconstruction is delayed until 6 to 8 weeks after injury. **Shelbourne et al.** in their study concluded that ACL reconstruction within first week of injury had a high incidence of arthrofibrosis compared to those who underwent surgery after 3 weeks. The injury to surgery interval of 6 to 8 weeks is necessary for the injured knee to become free of irritation (swelling, effusion, erythema).

Various graft fixation devices are available for soft tissue graft fixation which has led to an increased reliability on the use of soft tissue grafts.

Hristijai Kostov et al.[29] in their study comparing various modes of femoral hamstring graft fixation found that endobutton gives a better functional outcome than rigidfix and transfix fixation systems.

Ma et al.[30], in their prospective study comparing interference screw and endobutton fixation for femoral tunnels found that there was more tunnel widening in endobutton group but there was no difference in clinical outcome between the two groups.

Alexis Colin et al.[31] in a meta-analysis on best femoral fixation of hamstring grafts in ACL reconstruction concluded that no difference in functional outcome exists between interference screw fixation and non-interference screw fixation.

Chao Shen et al.[32] in their meta-analysis on biodegradable versus metallic interference screws found that no significant difference in knee joint stability or functional outcome between the two groups.

Petteri Kousa et al.[33], in their study comparing fixation strength of various hamstring tendon fixation devices, concluded that bone mulch screw was superior in securing hamstring graft to the femoral tunnel followed by endobutton.

Though there is problem of bungee effect of graft inside the femoral tunnel when an endobutton is used as it causes graft movements within the tunnel and tunnel widening, a study by **Benjamin Ma et al**[34]. showed that there was no difference in tunnel widening when using interference screw or endobutton.

Musahl V et al.[35] in their study found that femoral tunnel positioned in the anatomical footprint of ACL provides knee kinematics comparable to the intact knee than a tunnel placed for best graft isometry.

Hong Chul Lin et al.[36], in their cadaveric study, on comparing knee stability in anatomic and non-anatomic single bundle ACL reconstruction concluded that anatomic single bundle ACL reconstruction helps in restoring the knee joint stability comparable to the

native ACL under combined anterior and internal rotational forces than non-anatomic ACL reconstruction.

Richard B Meredick et al.[37] in their meta-analysis comparing single bundle and double bundle ACL reconstruction found no significant difference in KT-1000 arthrometer or pivot shift testing between the two groups.

Jeong Ku Ha et al.[38] in their study found no significant difference in clinical and functional outcome between single bundle and double bundle ACL reconstruction at a mean follow up of two years.

Mohser Mardan – Kivi et al.[39] in their study comparing anteromedial portal versus transtibial portal techniques for making femoral tunnels in ACL reconstruction concluded that anteromedial portal technique results in reduction of time to return to routine activities and better therapeautic outcomes and gives higher satisfaction rates.

J A Grant[40], in his study, concluded that home based physiotherapy is cost effective and not significantly inferior to supervised programs. Our patients were started on home based physiotherapy programs with emphasis on knee flexion and quadriceps strengthening

Anatomy :

Embryology:

The ACL has been identified in fetal development around 8 weeks. It has been hypothetised that the origin of ACL is from ventral condensation of fetal blastoma, and then as intercondylar space forms, there is gradual posterior migration[41]. The same blastoma condensation is the origin of the menisci. The anteromedial and posterolateral bundles of ACL can be seen from 16 weeks of gestation.

Gross Anatomy:

The ACL is a structure that connects the femur and tibia composed of numerous fascicles of dense connective tissue.

It originates on the posterior aspect of medial surface of lateral femoral condyle and inserts into wide area in the centre of the tibial plateau. The ACL has an oblique course within the knee joint passing from lateral and posterior at its origin to medial and anterior near its insertion.

The ACL is surrounded entirely by the synovium. Hence it is an extrasynovial intra-articular structure.

The ACL has a cross section of 44 mm^3 near midsubstance, which varies along its course. The cross section area near its origin and insertion is about three times the area in the midsubstance[42, 43, 44]. The approximate length of the ligament is 31 to 38 mm[45].

The ACL has two bundles

- Anteromedial
- Posterolateral

The anatomy of ACL attachment sites is important because of the emphasis placed on "anatomic positioning" of the graft during ACL reconstruction to produce an isometric position.

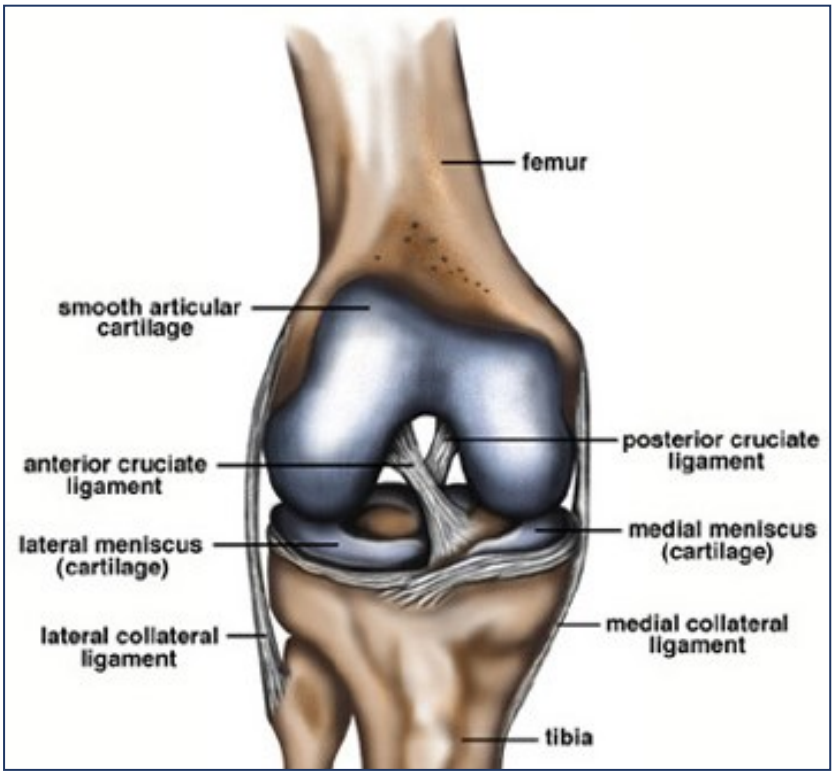


Fig 1: Anatomy of the knee joint

Femoral attachment:

ACL is attached on the posterior aspect of the medial surface of lateral femoral condyle. The origin of ACL in the femur is in the form of an ovoid area which has a length of about 18 mm and width about 11 mm[46].

The Anteromedial bundle occupies a posterior and superior in this ovoid area of origin in the lateral femoral condyle.

The posterolateral bundle occupies an anterior and inferior portion of the attachment site.

The Anteromedial and posterolateral bundle each occupy aboput 50 % of the total area of femoral origin[44].

Tibial attachment:

The ACL inserts into a broad area between the medial and lateral tibial spine. The ACL insertion is an axial area measuring 11 mm in the coronal plane and 17 mm in saggital plane[42, 43, 47].

The Anteromedial bundle insertion is in the anterior and medial portion of the above-mentioned area whereas the posterolateral bundle insertion is in posterior and lateral position and hence posteriorly the

fibres of posterolateral bundle are present close to the posterior root of the lateral meniscus.

The tibial attachment area is larger compared with femoral attachment area. (about 120%). But as in the case with femoral attachment area, the anteromedial and posterolateral bundles share equal portions of the attachment site[44].

The alignment of the anteromedial and posterolateral bundles change during the range of motion of the knee from extension to flexion. In full extension, the femoral attachment sites of anteromedial and posterolateral bundles are in vertical orientation and are parallel. But in 90 degrees of flexion, this orientation changes and the two sites are oriented horizontally. This change causes the twisting of anteromedial and posterolateral bundles and the two bundles cross each other.

Gabriel et al.[48] in their study, found that in extension, the posterolateral bundle is tightest and anteromedial bundle is relaxed, whereas the anteromedial bundle has maximum tightness in 60 degrees of knee flexion and posterolateral bundle is relaxed as the knee flexes.

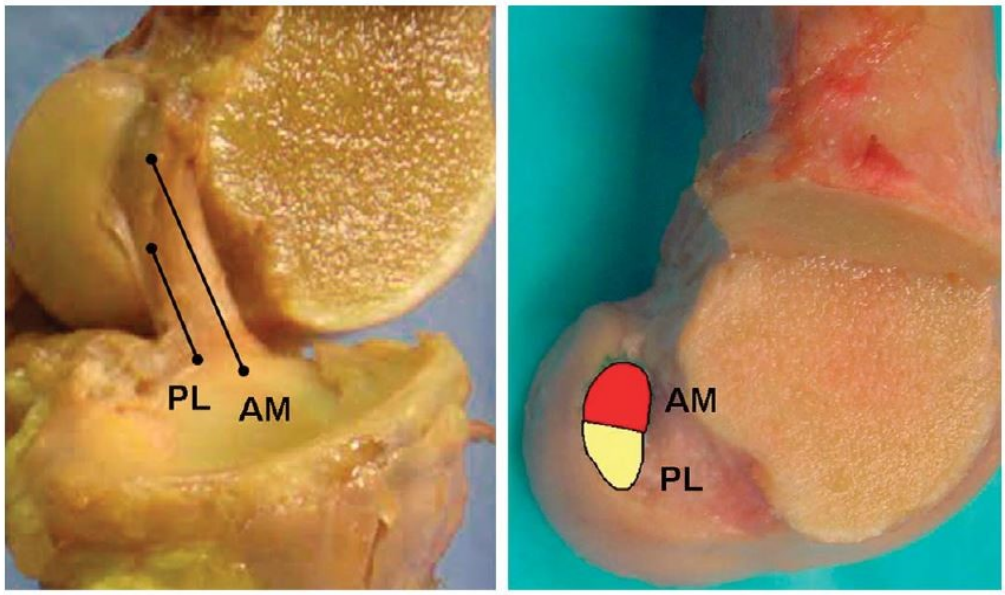


Fig 2: Crossing pattern of anteromedial (AM) and posterolateral (PL) bundles. With the knee in extension, theAM and PL bundles are parallel (A, left knee, medial femoral condyle removed) and the insertion sites are orientedvertically (B).

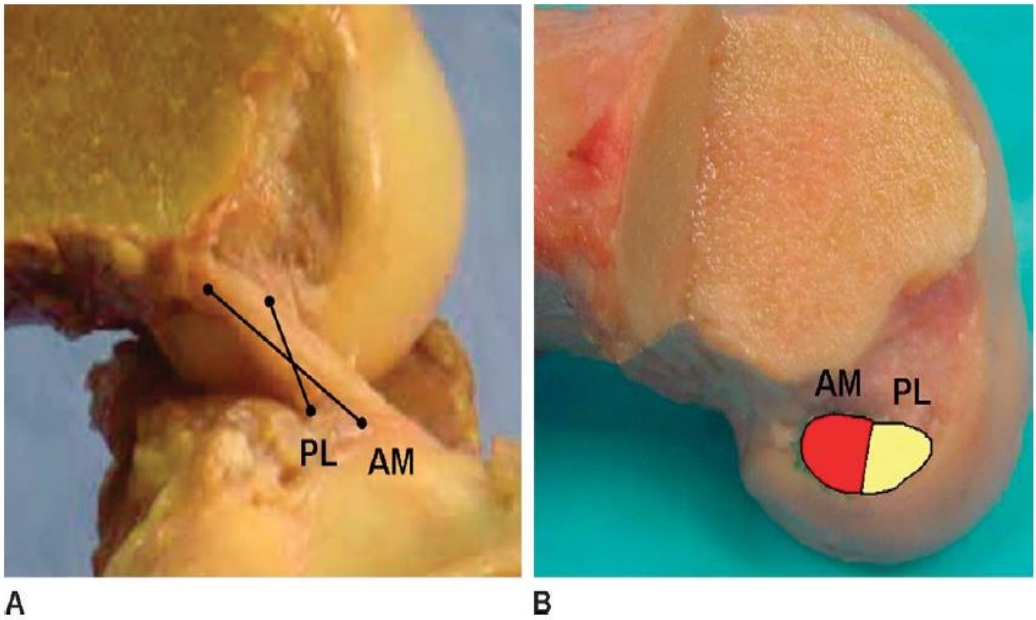


Fig 3: Crossing pattern of anteromedial (AM) and posterolateral (PL) bundles. With the knee in flexion, the AMand PL bundles are crossed (A, left knee, medial femoral condyle removed) and the insertion sites are orientedhorizontally (B).

During walking, the intact ACL maintains a balanceof rotation during the interval of swing phase to heelstrike. However, in the ACL-deficient knee, an increasedinternal rotation occurs between these phases of walking,which is maintained through the stance phase. Thus the ACL also contributes to the rotational stability of the knee[49].

As the insertional area of ACL is more (about 3.5 times) than that at the midsubstance, the stress of the ligament on the bone surface is reduced. The ligament gets attached to the bone by incorporating collagen fibres within the mineralised bone.

Blood supply:

The main arterial supply is through the ligamentous branch of middle geniculate artery which enters through the proximal third of the synovial sleeve. The synovial membrane which surrounds the ACL has a rich collection of blood vessels. A source of blood supply from the anterior vessels of the soft tissue and synovium of the retro patellar pad of fat has also been described recently. The blood supply from the femoral attachment site is less and almost no blood supply from the tibial insertion site. In spite of the various sources of blood supply described above, the predominant supply of nutrition for ACL is by diffusion from the surrounding synovial fluid.

Nerve supply:

The innervation of ACL is by the posterior articular nerve, which is a branch of the Posterior tibial nerve. The neural structures are found mostly near the attachment sites of ACL and in the sub synovial layers.

The receptors present in ACL are the ruffini receptors (function as stretch receptors) and free nerve endings. (which serve as nociceptors). Small nerve fibres have been found in the substance of the ACL that are responsible for pain and also have proprioceptive function.

Histology:

The ACL is composed of multiple fascicles which are covered by paratenon. Each fascicle is composed of numerous subfasciculi, which are covered by epitenon. They are made up of subfascicular units which contain numerous fibres and surrounded by the endotenon. The fibres are composed of numerous collagen fibrils which interlace to form complex networks.

The organisation of the ACL fibrils is unique. They may be helical and planar, parallel/twisted, non-linear networks. The fascicles that are located in the central portion of the ACL may be straight/undulated arranged in a planar wave pattern, while the fascicles in the peripheral portion are in a helical wave pattern. The mainstay of the wave and the

non-linear pattern of the ACL fibril has been interpreted as the "crimp" and "recruitment" respectively[50].

The crimp denotes the sinusoidal pattern that occurs regularly in the matrix. The pattern in the matrix mimicking accordion act as a buffer so that minimal elongation occurs without damage to the fibres. Thus, it acts as a "shock absorber" along the length of the tissue[51]. So, when a tensile stretch occurs, the fibril "crimp" gets straightened initially by small loads, afterwards loads that are larger are required for the elongation of these fibrils. When larger loads are applied, more number of fibrils become load bearing ("recruited") and the tissue stiffness increases gradually, thus a non-linear load elongation curve results.

Microscopically, there are 3 zones present within the ACL

1) Proximal part:

   - highly cellular
   - contains type 2 collagen, glycoproteins (fibronectin and laminin), fibroblasts

2) Middle part

   - contains fibroblasts (fusiform and spindle shaped)
   - collagen fibres are present in high density.

- elastic fibres - withstand recurrent maximal stress
- oxytalan fibres - withstand multidimensional stresses

3) Distal part

- most solid
- abundance of chondroblasts and ovoid fibroblasts
- collagen fibres are present in low density in contrast to middle part

The site of femoral and tibial attachment of ACL has the structure of chondral apophyseal enthesis.

- 1st layer - ligament fibres
- 2nd layer -non mineralized cartilage zone (fibrocartilaginous cells that are arranged in the collagen bundles)
- 3rd layer -mineralised cartilage zone
- 4th layer -insertion of the mineralised fibrocartilage into the subchondral zone[52]

Due to the gradual transition from rigid bony tissue to ligament structures, the change in stiffness is gradual, preventing stress concentration at the attachment sites.

Functions of ACL:

The ACL helps to maintain the static and dynamic equilibrium of the knee in association with other structures around the knee joint.

The ACL has two complementary roles

- Proprioception
- Mechanical function

The proprioception function can be ascertained by the fact that histological observations demonstrate nerve endings in the ACL.

The mechanical functions of ACL have the following characteristics:

- The anteromedial bundle of ACL provides resistance against anterior translation of tibia on femur in 90 degrees of knee flexion
- The main resistance to hyperextension is provided by the posterolateral bundle

- The ACL provides rotatory control of the knee by acting as a check to internal axial rotation.

- The ACL acts as secondary restraint against valgus and varus stresses in all degrees of knee flexion

- Tension in the ACL in turn does the fine tuning for the screw home mechanism, thus stabilising the joint as it approaches terminal extension

Evolution of arthroscopy[53]

The arthroscopy is considered one of the greatest innovation in the diagnosis and treatment of orthopaedic patients during the 20th century. The word "arthroscopy" is derived from the Greek work "arthro" which means "joint" and scope which means "to view".

The history of arthroscope dates back to 1912. In 1912, Danish surgeon "**Severis Nordentoft**" presented a paper titled "On the endoscopy of closed cavities using my Trocar endoscope". The term used by him was "arthroscopia genu". The instrument used by him was similar to the laparoscope designed by Jakobeus. Since his was the only one paper dealing in endoscopy his contribution was soon forgotten.

In 1918, **Takagi** from Japan used a cystoscope to examine a cadaver knee. Because of the lack of success with the instrument, he assisted in the designing of the arthroscope in 1920. But the diameter of the instrument was large and impractical to use. In 1931, Takagi developed a arthroscope 3.5 mm in diameter. He also described the use of saline solution for distention of knee and better visualisation.

Meanwhile a swiss surgeon "**Eugene Bircher**" used the laparascope to visualise the meniscal lesions of the knee joint. He termed the procedure as "arthroendoscopy".

Due to their early contributions to the development of arthroscopy, Takagi and Bircher are considered as the “Father of arthroscopy”.

In 1931, **Michael Burman** published a historical paper “Arthroscopy or the direct visualisation of the joints”. He also published twenty coloured aquarelles of arthroscopic findings of various joints which were the first arthroscopic images ever published.

In 1955, the first use of arthroscope for therapeutic purposes was by **Masaki Watanabe** who did an arthroscopic removal of a xanthomatous tumour from the superior recess of the knee. He was the first to perform arthroscopic partial meniscectomy in 1962. He is rightly called the “Father of modern arthroscopy”. He developed the no. 21 arthroscope which served as a model for production.

The first partial meniscectomy in North America was done by **O’Connor**. The first rod lens in the operating arthroscope was introduced by him.

The motorised shaver instruments were first developed by Dr. Lanny Johnson in 1976. The first arthroscopy was organised by **Dr.John Joyce** in 1972.

In 1970s, the surgical arthroscopy developed with the advent of fibre optics and use of television technology which allowed the surgeons

to view the joint in the television monitor rather than direct visualisation with the eye thereby freeing the surgeon's hands.

The future of arthroscopy is travelling towards development of three dimensional viewing during arthroscopy and manual movable optics with 0 to 90 degrees rotation. Virtual Reality Arthroscopic Training Simulator (VRATS) is also coming up for the training of the surgeons in arthroscopic procedures.

Mechanism of injury:

The common modes of injury of ACL are

1) Direct contact (30%)
2) Non contact (70%)

Women are more susceptible to ACL injury than men. This may be due to

- Women have a smaller intercondylar notch
- Lesser strength and smaller size of ACL in females
- Females have a greater Q angle compared with males
- Hormonal factors may cause laxity of ligaments
- Neuromuscular risk factors

In the absence of the capsule and ligamentous structures supporting the knee joint, it is inherently unstable. The medial and lateral structures give Varus and valgus stability whereas the cruciate ligaments give anteroposterior and rotatory stability with the help of capsuloligamentous structures. On the basis of position of the knee, the primary and secondary stabilisers vary. The ligament injuries occur in a position of knee flexion as the capsule and other ligamentous structures are relaxed in this position and the femur rotated on the tibia.

The most common mode of injury is non-contact deceleration with valgus and twisting movement. In cases of isolated ACL injury, the most common mode of injury was deceleration, internal / external rotation and hyperextension which occurs when landing on the ground from a jump or a sudden change in direction during running.

Valgus forces on the knee do not create a serious injury till medial collateral ligament is intact, although when MCL is injured, with continuing valgus thrust, the ACL gets injured. When a rotation component occurs along with the above, the medial meniscus gets caught between the tibial and femoral condyle articulating surfaces producing a classical unhappy triad of O' Donoghue.

Classification of ACL injuries:

According to the American Medical Association handbook, Standard Nomenclature of Athletic Injuries, a sprain is defined as an injury limited to ligaments (connective tissue attaching bone to bone). Sprains are classified into three degrees of severity. A first-degree sprain of a ligament is defined as a tear of a minimal number of fibers of the ligament with localized tenderness but no instability; a second degree sprain, as a disruption of more ligamentous fibers with more loss of function and more joint reaction with mild-to moderate instability; and a third-degree sprain, as a complete disruption of the ligament with

resultant marked instability. These often are classified as mild, moderate, and severe for first-, second-, and third-degree sprains, respectively. Third degree sprains, that is, those demonstrating marked instability, can be further graded by the degree of instability demonstrated during stress testing. With 1+ instability, the joint surfaces separate 5 mm or less; with 2+ instability, they separate 5 to 10 mm; and with 3+ instability, they separate 10 mm or more. A standardized classification is important for accurate communication, and although it obviously is not always precise, it does provide a workable scale for clinical purposes.

The treatment of first-degree sprains is symptomatic only; a person with a first-degree sprain usually can return to full activity within a few days. Second-degree sprains with moderate local injury and joint reaction but without demonstrable instability can be treated conservatively, but the ligament needs protection. A return to vigorous activity must be delayed until the inflammatory reaction has subsided and rehabilitation has been completed. A functional brace that restricts motion through certain arcs can provide protection. Third-degree sprains with complete disruption of the ligament may require surgical repair unless there is a specific contraindication

Natural history:

Controversy exists regarding the natural history of ACL tear since the studies presently available are biased towards symptomatic patients who come for treatment.

Various studies have proved that if a person with ACL injury resumes sporting activities and experience repeated episodes of instability, he will have meniscal tears and osteochondral injuries that will ultimately result in arthritis. The incidence of second ACL tear in the first year after undergoing reconstruction and return to athletic activities is fifteen times more than in previously uninjured patients.

The incidence of meniscal injuries that occur with acute ACL injuries is around 50 to 70% and lateral meniscus is the one commonly affected in acute injuries. The incidence of late meniscal injury in the ACL injured knee is high because of the abnormal loading and shear forces. Medial meniscus is the one commonly injured in chronic ACL tears due to its firm attachment to the capsule.

Osteochondral change occurs in 21 to 31% of patients after initial ACL injury. MRI is a sensitive tool for identifying the bony injuries in patients with both acute and chronic ACL injuries. These osteochondral abnormalities may serve as precursors of osteoarthritis.

Clinical evaluation

The clinical evaluation of an ACL injured patient starts with detailed clinical history. The usual history consists of a non contact deceleration injury or jumping action. The patient usually hears or feels a popping in the knee at the time of injury. After the injury, the patient often falls to the ground and is not able to get up immediately. The patient is not able to resume his activity immediately and walking is also mostly difficult. After a few hours, haemarthrosis develops. In the above circumstances, the possibility of an ACL injury is about 70%. If physical examination is done before haemarthrosis develops, then it is easier.

The common symptoms at presentation include pain and giving way of the knee joint. Non-contact injuries usually cause ACL tears whereas contact injuries cause injury of multiple ligaments.

The symptoms of locking episodes, click or clunk are indicative of associated meniscal injuries.

The knowledge about patient's occupation and personal requirements helps in individualising patient treatment.

Physical examination:

This includes inspection, palpation, measurements and movements of the knee joint. Then the tests for cruciate ligaments, collateral ligaments and menisci are done which help in diagnosis and further plan of management.

The various tests performed for ACL insufficiency are as follows.

Anterior Drawer test:

The patient is positioned supine on the examination table with the hip in 45^{o} flexion and knee in 90^{o} flexion. The examiner sits on the dorsum of foot to stabilise it. Then relaxation of the hamstring muscles are confirmed by placing the hands behind the knee. Then the proximal portion of the leg is gently pulled and pushed anteriorly and posteriorly. The degree of movement of the tibia on femur is noted. The same is done in 30^{o} external rotation and 30^{o} internal rotation.

A displacement of 6 to 8 mm more than that of contralateral knee indicates ACL injury. Posterior sagging of the tibia should be looked for before doing the anterior drawer test, else a false positive result may be obtained.

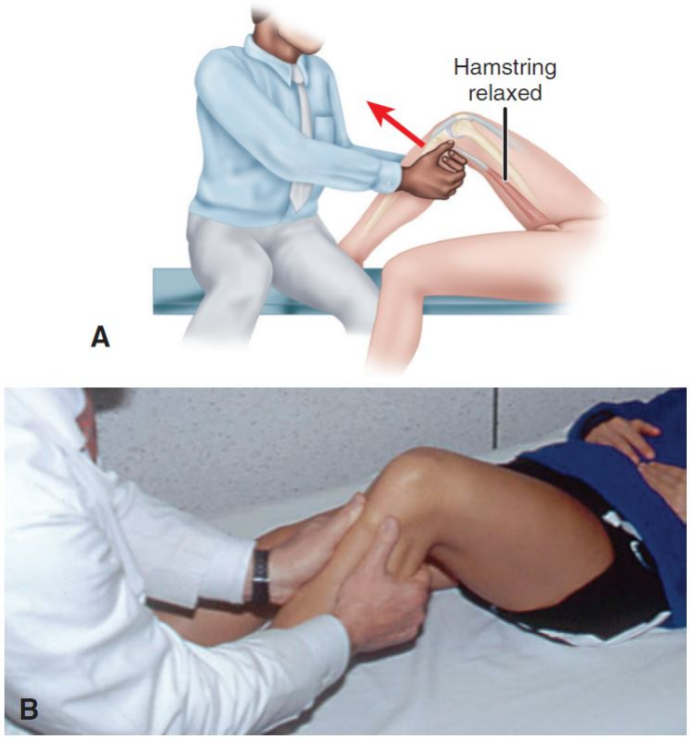


Fig 4: Anterior Drawer Test

Lachman test:

The anterior drawer test cannot be done in an acute painful knee as 90°flexion could not be obtained. In this circumstance, Lachman test may be used. The patient lies supine with the limb in mild external rotation and knee between full extension and 15 ° of flexion. The femur is stabilised with one hand and with the other hand, the proximal portion of tibia is lifted forward so as to translate it anteriorly.

The hand holding the proximal tibia should be such that thumb lies on the anteromedial joint margin. The anterior translation of tibia with a soft end point is suggestive of ACL injury. The Lachman test is more sensitive than anterior drawer test in diagnosis of ACL injury.

Fig 4: Lachman Test

Slocum Anterior Rotatory Drawer test:

The anterior drawer test is done in 15 ^{o} internal rotation, neutral rotation and 30 ^{o} external rotation.

If anterior drawer test is positive in neutral rotation and is increased in 30 ^{o} external tibial rotation and reduced in 15 ^{o} internal rotation, then it indicated anteromedial rotatory instability.

Pivot shift test:

This is an indirect test of ACL injury that is used to elicit the subluxation that occurs when the ACL is not functioning.

The classic pivot shift was described by Callway and McIntosh. The patient is placed supine, the lower limb is lifted from the table by the examiner by holding the foot and it is internally rotated. In a properly relaxed limb, the knee falls into full extension.

If full extension of the knee does not occur (due to pain or swelling), the test may not be accurate.

If the ACL is torn, gravity causes the femur to fall posteriorly that results in anterior subluxation of tibia over femur. The other hand of the examiner is placed on the lateral aspect of proximal third of the leg and a valgus force is applied, at the same time flexing the knee. In 20 to 30^{o} of knee flexion, the anteriorly subluxated tibia reduces into normal position, with a sudden jump or shift.

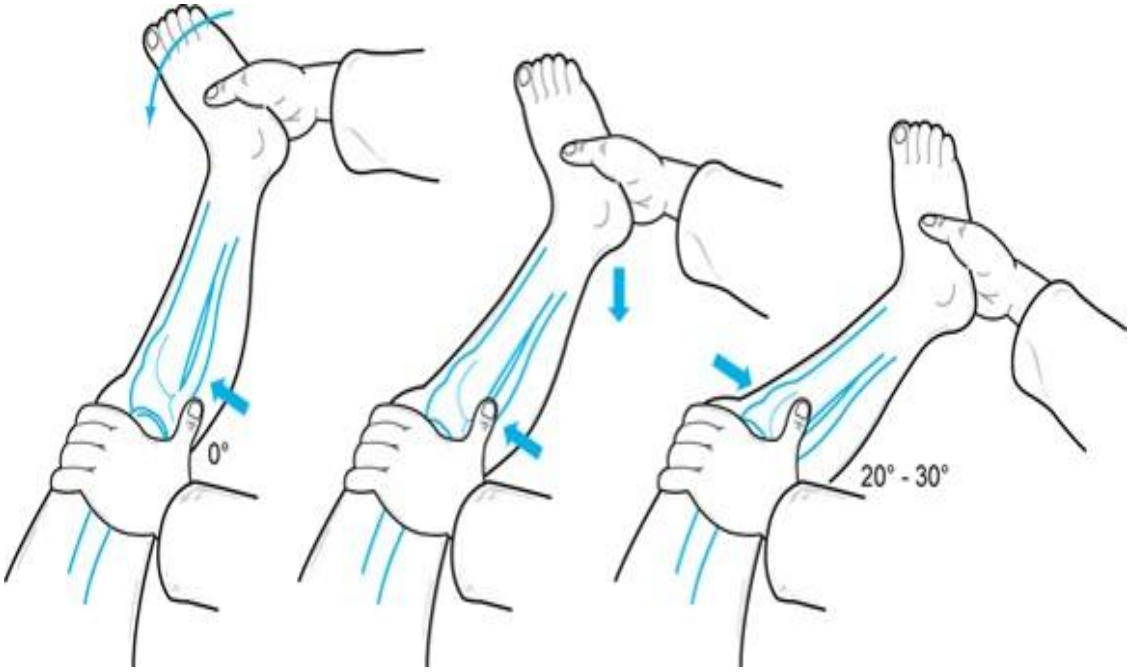


Fig 5: Pivot Shift Test

Jerk test:

The test first described by Hughston, is the reverse of the classic pivot shift test. The patient is placed supine, with the knee in 90° flexion and tibia internally rotated. Valgus stress is applied with the other hand, knee is then extended gradually. If the tibia subluxates anteriorly with sudden jerk at around 30° of flexion, then the test is considered positive.

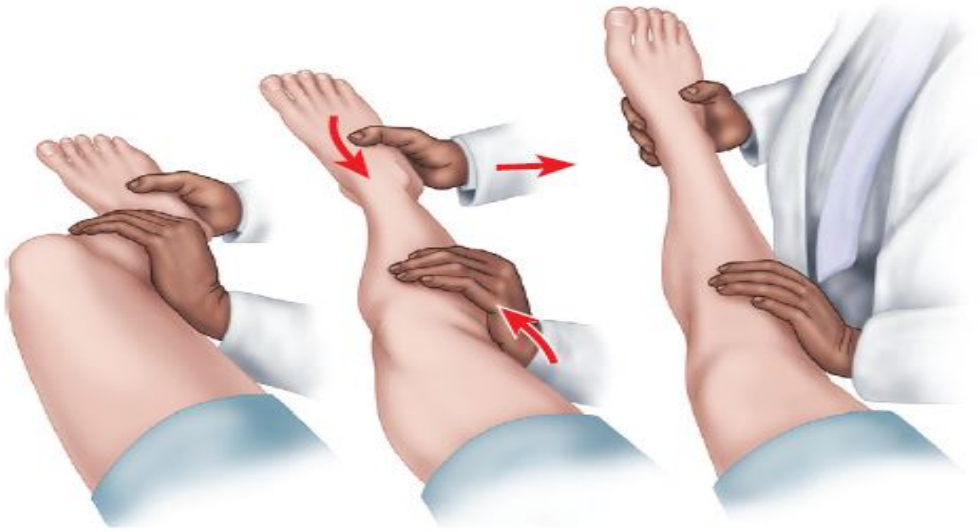


Fig 6: Jerk test

Slocum's method:

The patient is positioned in lateral decubitus position with pelvis tilted 30° posterior and knee in full extension and medial side of foot kept firm on the examination table. The examiner then slowly presses the knee into flexion. The test is considered positive when reduction occurs in 25 to 45° of knee flexion. The advantages of Slocum's method is that lesser degrees of instability can be made out and it is less painful.

Flexion rotation drawer test:

It is a modification of pivot shift test which is gentler. The ankle of the patient is held by the examiner with both hands. The valgus, internal

rotation and flexion are indirectly applied at the ankle. This method is more gentle and less threatening to the patient.

Fig 7: Flexion rotation Drawer test

The other tests to find associated injuries are as follows:

Valgus and Varus laxity

In the valgus stress test, a force directed at the midline is applied at the knee while an opposing force directed away from the midline is applied at the foot or ankle. The varus stress test is exactly the opposite: a force directed away from the midline is applied at the knee while an opposing force directed toward the midline is applied at the foot or ankle.

Valgus Stress Test:

The valgus stress test assesses the integrity of the *MCL complex*. The superficial MCL is the primary restraint to valgus stress at the knee. The deep fibers of the MCI. (meniscofemoral ligament and menis-cotibial ligament) act as secondary restraints to valgus stress. The posteromedial capsule is an important restraint to valgus stress when the knee is in full extension; when the knee is in flexion, the posteromedial capsule is relaxed and therefore ineffective in resisting valgus stress. Finally, the cruciate ligaments come into play as tertiary restraints against extreme valgus stress once the medial structures have failed.

To perform the valgus stress test, have the patient lie supine and relaxed on a flat examining table. The examiner raises the patient's lower limb off the examining table by grasping it gently at the ankle. The patient's muscles should be fully relaxed so that the knee falls into complete extension. When the patient is properly relaxed, the lower limb feels like a dead weight. If the examiner senses that the patient is assisting in raising the leg, it is important to encourage the patient to relax fully before proceeding with the rest of the examination. If the patient finds relaxation difficult, the test may be performed without raising the limb by abducting it until the knee is at the edge of the table so that the patient's thigh is still supported by the table.

With the patient's knee in full extension, the examiner applies a gentle inward force at the knee and a reciprocating outward force at the ankle. The force is then relaxed. The examiner both looks and feels for a separation of the femur and the tibia on the medial side of the knee in response to the valgus stress. In the normal knee, virtually no separation of the medial tibia and femur is felt when the knee is in full extension. In the abnormal case, the femur and the tibia are felt to separate when the valgus stress is applied and to clunk back together when the stress is relaxed. The same test should be conducted on the opposite, presumably normal, knee for comparison.

Increased laxity Co valgus stress with the knee in full extension signifies damage not only to the superficial and the deep MCL fibers but also to the posteromedial capsule. In such a knee, the incidence of concomitant injury to one or both cruciate ligaments is extremely high. If valgus stability in full extension is normal, the examiner then flexes the patient's knee about 10° or 15° and repeats the test. Flexing the knee relaxes the posteromedial capsule and concentrates the force on the MCL. (If the examiner flexes the knee too much, the limb tends to internally rotate at the hip when a valgus force is applied.) Again, the examiner looks and feels for abnormal separation of the medial tibia and the femur in response to the valgus stress and the feeling of the two bones clunking

back together when the stress is relaxed. The combination of normal valgus stability when the knee is fully extended and abnormally increased valgus laxity when the knee is flexed suggests more isolated damage to the MCL with an intact posteromedial capsule.

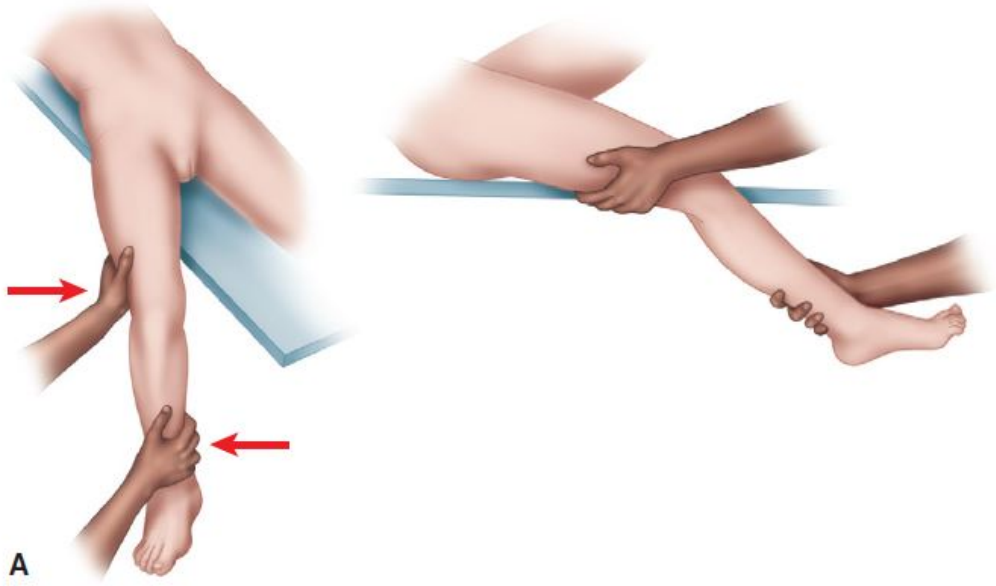


Fig 8: Abduction stress test

Varus Stress Test:

The varus stress test is the counterpart of the valgus stress test for detecting injury to the *LCL complex*. Again, the patient lies supine and fully relaxed. The examiner raises the patient's lower limb off the examining table by grasping it at the ankle. As in the valgus stress test, the knee is first tested in full extensionand then in about 10° or 15° of flexion. This time, the examiner applies an outward force at the knee and

a reciprocating inward force at the ankle. Again, the examiner both looks and feels for abnormal separation of the femur and the tibia, this time on the lateral side of the knee, in response to the varus stress. In the normal knee, virtually no separation of the lateral tibia and the femur are felt when the knee is in full extension. When the lateral ligamentous structures are torn, the femur and the tibia are felt to separate abnormally when the stress is applied and to clunk back together when the stress is relaxed.

The major difference between the varus and the valgus stress tests is that most patients have more natural laxity of the lateral ligaments than the medial ligaments. This natural laxity is evident when the varus stress test is repeated with the knee in flexion when the varus stress is applied, a definite separation is felt, and when the stress is relaxed, the femur and the tibia clunk back together. This separation is probably about 3 mm to 5 mm in the average normal knee. Thus, it is extremely important to compare the two limbs to verify that the varus laxity felt is increased compared with the other side and not just a consequence of the patient's physiologic varus laxity. As in the valgus stress test, increased varus laxity in full extension implies more extensive injury, usually involving the posterolateral ligament complex and one or both cruciate ligaments.

Fig 9: Adduction stress test

McMurray's Test:

For the **McMurray test,** the supine patient is asked to flex the involved knee as far as possible. To test the **medial meniscus,** the examiner grasps the patient's hindfoot and externally rotates the foot while placing a varus stress at the knee to compress the medial meniscus. The knee is then passively extended while the examiner palpates the medial joint line with the index finger of the other hand. In McMurray's original description, the test is positive if the patient complains of pain localized to the medial joint line and the examiner feels a click in this location. The true McMurray click is only occasionally felt, although joint line pain is commonly elicited in the absence of such a click and

often indicates a meniscus tear. The pain of osteoarthritis can sometimes also be elicited by the McMurray test.

To test for a lateral meniscus tear, the examiner applies an internal rotation-valgus force to the hyper-flexed knee. In the presence of a lateral meniscus tear, the patient reports pain localized to the lateral joint line as the knee is passively extended. A click is only rarely felt with the lateral McMurray test.

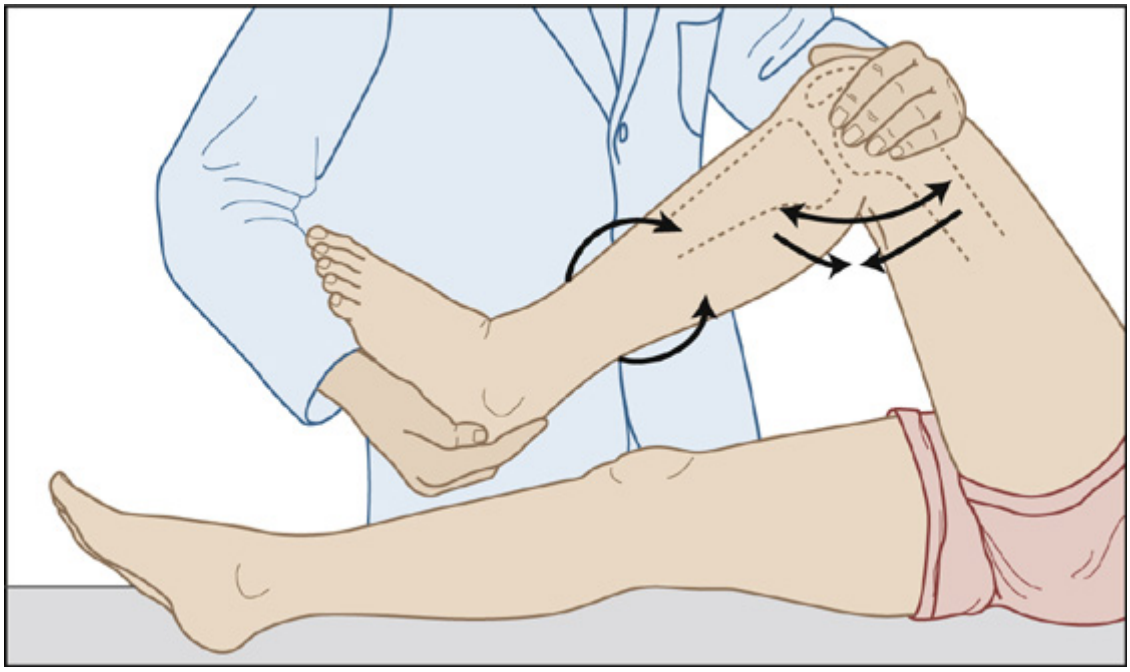


Fig 10: McMurray's test

Apley's Grind Test:

The Apley test for posterior meniscus tears has two parts. In both portions, the patient is asked to be prone and to flex the knee to 90°. The examiner then grasps the foot and asks the patient to relax. For the

distraction portion of the test, the examiner stabilizes the patient's thigh using downward pressure from the examiners own knee while pulling the patient's foot upward to distract the patients knee. When ligaments are torn, this part of the test is painful. The examiner then alternately externally and internally rotates the patient's foot, the examiner proceeds to the compression test, pushing downward on the patient's foot to compress the knee while alternately externally and internally rotating the foot. During the compression test, pain localized to the medial joint line (usually produced by external rotation) suggests a medial meniscus tear, whereas pain localized to the lateral joint line (usually produced by internal rotation) suggests a lateral meniscus tear.

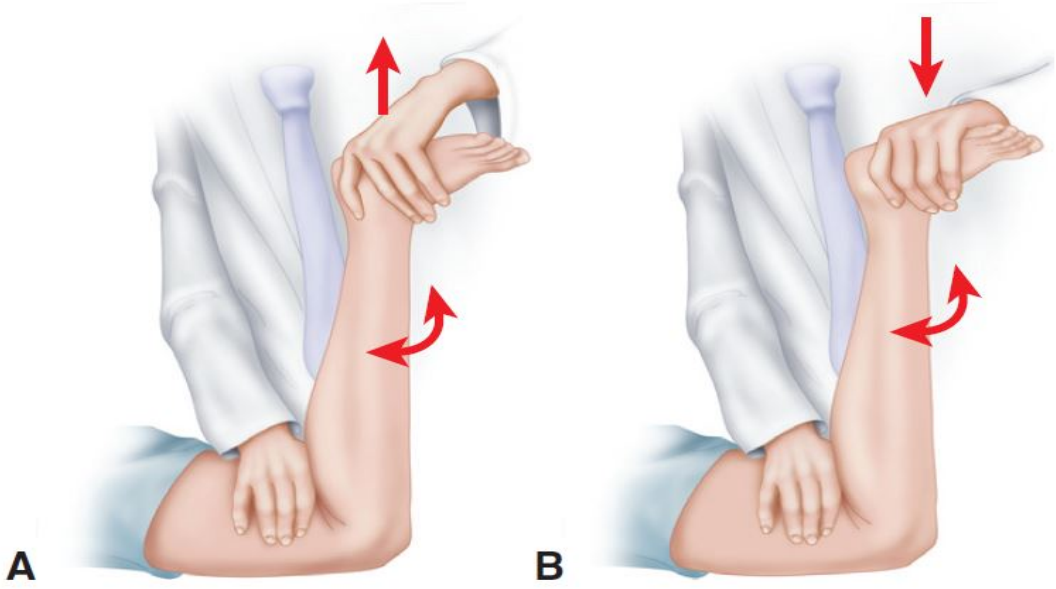


Fig 11: Apley's Grind Test

Radiographic evaluation

The AP and lateral radiographs of the knee are necessary to look for fractures, degenerative changes and other associated injuries. The radiographs may reveal an avulsion fracture of the lateral tibial rim (known as Segond's fracture). Tibial spine avulsion fractures can also be seen on radiographs. These are more common in skeletally immature patients. Stress lateral radiographs can be used to show ACL injury radiographically while the anterior drawer test is done. More than 5mm anterior translocation is considered abnormal. A difference of more than 3cm when compared with contralateral knee is also considered significant. Deep lateral femoral notch sign (prominent lateral condylopatellar groove) which occurs due to pivot shift injury can also be seen sometimes in X rays.

Magnetic Resonance Imaging:

The MRI provides a non-invasive visualisation of the ACL and other soft tissue structures in the knee joint thereby helping the preoperative assessment of the patient.The minimal protocol required for imaging of ACL include T2 weighted sequence in two to three arthrogonal planes .

In a sagittal image, the normal ACL can be seen as a solid or striated band with slight divergence distally. The ACL is often straight, sometimes mild convex inferior sagging may be seen in normal ACLs.

The ACL has somewhat higher signal intensity than PCL. In a coronal section, the ACL can be seen well but the band is usually attenuated and less bulky when compared with sagittal plane.

In a study by Adriaensen et al.[54], the anteromedial and posterolateral bundles of ACL can be visualised in MRI in 94 % of patients in three tesla field strength.

The most common sites of occurrence of ACL tears is the middle aspect of the ligament. The proximal part near the origin is injured in 7 – 20 % of cases while distally at the site of tibial attachment the frequency of injury is around 3 to 10 %.

Primary signs of ACL injury:

- Non visualisation of the ACL in its usual location
- Focal interruption
- Angulation / non- linearity
- Flattened axis of distal ACL with poor visualisation of proximal ACL (Abnormal ACL axis). The ACL axis is considered abnormal

if it is more horizontal than Blumensaat line on a sagittal image. (Blumensaat line – line along the intercondylar roof)

Fig 12: Nonvisualization as a primary sign of ACL tear

Fig 13: Flattened axis of the distal ACL with poor visualisation of proximal ACL as a primary sign of ACL tear.

Fig 14: Angulation/nonlinearity as a primary sign of a ACL tear

Secondary signs:

The signs that denote an ACL injury other than the abnormalities of the ACL proper are called secondary signs.

- Pivot shift bone bruises in the femur and tibia
- Pivot shift osteochondral fracture of the lateral femoral condyle
- Countercoup medial bone bruise of the tibia
- Anterior translation of tibia on sagittal MRI
- Uncovered meniscus sign – when a tangential line is drawn to the posterior margin of tibia, it passes through the posterior horn of

lateral meniscus. In a normal knee, this tangent line will pass posterior to the meniscus

- Vertically oriented lateral collateral ligament
- Segond fracture
- Tibial spine fracture
- Redundant PCL (unusually arched PCL)
- Arcuate fracture of the fibular head

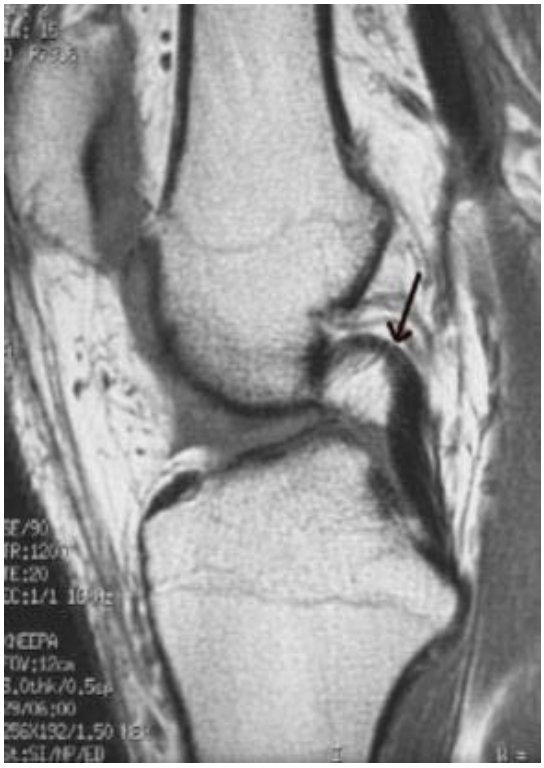


Fig 15: PCL redundancy as secondary sign of ACL tear

Fig 16: Segond fracture in a patient with Anterior Cruciate Ligament tear

Partial ACL tears:

These are common with around 10 – 43 % of the ACL tears being partial. Tears that involve <25 % of ACL when viewed arthroscopically have a good prognosis, tears that involve 50 – 75 % of ACL have a high chance of progression to complete tears[55].

Chronic ACL tears:

The signs of chronic ACL insufficiency are similar to acute tears except for the absence of bone bruises and oedema in the knee joint.

Empty notch sign may be present in which the MRI shows only fat in the lateral intercondylar notch and ACL is absent.

Using direct signs, the sensitivity of MRI for detecting ACL injuries vary from 92 – 94 % and specificity ranging from 95 – 100%[56].

MATERIAL AND METHODS

This a prospective study conducted in Coimbatore Medical College and Hospital, Coimbatore from June 2015 to September 2017.

There were 20 patients included in our study of which 17 patients (85%) were male and 3 (15%) were female. 11 patients (60%) had right side injury while 9 (45%) had injury to the left knee. The patients were followed up for an average duration of 17.6 months with minimum follow up of 7 months and maximum follow up of 27 months.

All young and middle age patients presenting with unilateral knee complaints and history of trauma to the knee in the orthopaedic emergency and outpatient departments in Coimbatore Medical College and Hospital, Coimbatore were evaluated by a thorough general and local examination of the knee. In a relaxed patient and in supine position, the uninjured knee was examined first to establish ligament excursions after which the affected knee was examined.

The following specific tests were performed for diagnosing anterior cruciate ligament deficiency:

1. Lachman test
2. Anterior drawer test
3. Pivot shift test

Injuries to the associated structures were assessed by performing the following clinical tests.

1. Valgus/ varus stress test (for collateral ligaments)
2. McMurray's test/ Apley grinding test (for menisci)
3. Posterior drawer test (for posterior cruciate ligament)

Routine radiographs of both knees in standing position in anteroposterior view and lateral view of the affected knee were taken. MRI of the knee was done in all ACL torn cases for confirmation.

Inclusion criteria:

The following patients were included

- Clinical /MRI evidence of symptomatic individuals with anterior cruciate ligament insufficiency
- Patients between age 20 to 40 (skeletally matured patients)
- Associated with medial or lateral meniscus tear
- Associated Garde I and II MCL and LCL injuries
- No history of previous surgery in the knee
- A normal contralateral knee

Exclusion criteria:

- Asymptomatic individuals
- Patients with systemic diseases compromising their pre-anaesthetic fitness
- Associated with PCL tear
- Associated Grade III MCL and LCL injuries
- Patient with osteoarthritic knee
- Patients with associated fracture of tibial plateau
- Patients with local skin infections

Pre-operative work up:

Patients with ACL tear proven clinically and radiologically are admitted in Department of Orthopaedics, Coimbatore Medical College and Hospital, Coimbatore. Routine investigations like haemoglobin, total and differential counts, platelet count, chest X ray, ECG were taken and anaesthetic assessment for regional and general anesthesia was done.

Pre-operative Rehabilitation:

1. Pre-operative strength and range of movement of knee joint were measured and documented

2. Static and dynamic quadriceps exercise were taught to patients while awaiting surgery

3. All patients were enlightened on post – operative rehabilitation

Consent:

All patient in this study were explained about the injury, diagnosis, various management options, complication of non - operative treatment and operative management, per-operative and post-operative complications, donor site morbidity, injury to surrounding structures, infection, compartment syndrome, anaesthesia risks, post - operative knee pain, restriction of range of motion.

Consent for surgery was obtained for all the patients who were included in this study. All consent was obtained prior to surgery. Patients and their attenders were well explained about the advantages and disadvantages of procedure. Risk benefit ratio was explained.

Surgical Technique:

Instrumentation:

Many specialised instruments are required for arthroscopic anterior cruciate ligament reconstruction. An arthroscopic system consists of

1. Television monitor

2. Camera
3. Light source and fibre optic light source cable
4. Arthroscope
5. Shaver system and hand piece
6. Tourniquet (pneumatic)

Equipments needed for surgery include

- 2.4 mm drill tip guide pins
- Trocar, cannula, ACL probe
- Meniscus punch
- 4mm/5mm shaver burr
- Tibial aiming guide
- Cannulated headed reamers (5 to 10 mm)
- Femoral entry point aimer (6mm / 7mm offset)
- Extra long 2.4 mm guide pin with suture eye (beath type guide pin)
- 4.5 mm cannulated reamer for passage of endobutton
- Depth guage
- Sizing master board

Implants:

The various fixation options available for soft tissue grafts can be classified into direct methods and indirect methods. The commonly used direct fixation devices are

- Interference screws
- Staples
- Washers
- Crosspins

Indirect fixation devices used are

- Polyester tape/titanium button
- Suture post

In our study, we used interference screws and endobutton.

Endobutton:

The endobutton helps to ensure that maximum portion of graft is within the tunnel. The endobutton has four holes with centre two holes used for creating the loop for the quadrupled graft. The two peripheral holes allow the passing sutures that aid in the flipping of endobutton. It is stronger than the interference screw in withstanding cyclical load.

The advantages of endobutton are

- Smaller size
- Highly stable fixation
- Easy placement
- Compatible with most autografts
- No interference with revision surgery

The disadvantages are

- Wide separation of fixation points
    - “windshield wiper” effect (movement of the graft parallel to the bone tunnel) and “Bungee effect” (movement of the graft perpendicular to the tunnel axis) will result in tunnel widening
- Need for special instruments to prepare the graft

Fig 17: Endobutton

Interfernce screw:

These are direct fixation devices that help in holding the graft. It is inserted between the graft and bone tunnel. The various types available are the titanium interference screw and bioabsorbable interference screw.

The advantages of interference screw are

- Low profile
- Allows intra-articular placement

The disadvantages are

- Risk of injury to the graft
- Risk of losing the screw in the posterolateral recess during insertion

- Risk of blowout of posterior cortex
- Difficulty in locating the screw during revision if the screw was driven deep into the tunnel
- The graft may change its position while advancing the screw
- Graft advancement may occur if tension is applied when inserting the screw
- Screw laceration of the passing suture may occur

Fig 18: Titanium Interference screw

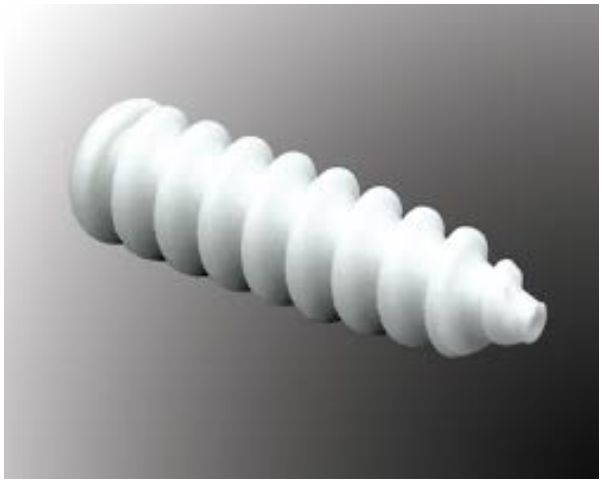


Fig 19: Biodegradable screw

Biodegradable screws:

These have a fixation strength comparable to that of metal screws.

The advantages of bioscrews are

- No removal is necessary

- No interference with radiological studies like MRI

The disadvantages are

- Risk of foreign body reactions
- Viscoplastic deformation which may weaken the fixation strength of the implant

Portals in arthroscopy

Adequate illumination, joint distension and proper positioning of portals for the entry of arthroscope and accessory instruments are important in arthroscopy. The precise placement of portals is necessary since improper placement results in inability to see the joint and difficulty to maneuver the instruments within the joint. If an arthroscope is forced through an improperly placed portal, not only may injury to the joint occur but also the instrument may be damaged

The portal entry points should be precisely marked before joint distension. The outlines of the following bone and soft tissue landmarks are drawn – patella, patellar tendon, medial and lateral joint line , posterior contours of the medial and lateral condyles of the femur . The surgeon should mark the portals and landmarks before and after distension to ensure correct placement of portals.

It has been found in a study by Stetsin and Templin that knee arthroscopy with two portals had an earlier rehabilitation time and quicker return to activity compared to arthroscopy with three portals. This was because the vastus medialis obliqus was violated when using three portals.

Standard portals:

The standard portals include,

*anterolateral

*anteromedial

*superolateral

*posteromedial

Anterolateral portal

This is the portal most commonly used by the surgeons for diagnostic arthroscopy. Almost all the structures within the knee joint may be visualised through this portal except PCL and the anterior part of the lateral meniscus. The location of this portal is 1cm superior to the lateral joint line and 1cm lateral to the patellar tendon. The level of the portal should be approximately 1cm distal to the inferior pole of the patella. Injury to the anterior horn of the lateral meniscus may occur if the

port is placed close to the joint line. If the port is placed too close to the patellar tendon, the scope may penetrate the fat pad resulting in difficult viewing and manoeuvring of the scope within the joint.

Anteromedial portal:

This portal is mainly used for additional visualisation of the lateral compartment and also for palpating the medial and compartment structures with the use of the probe. The portal is situated 1cm superior to the medial joint line, 1cm distal to the inferior pole of the patella and 1cm medial to the patellar tendon. The exact placement of the portal can be confined by placing a spiral needle percutaneously which is visualised via the anterolateral portal.

Posteromedial portal

The location of this portal is in a small triangular spot which is bound by the posteromedial edges of the femoral condyle and the tibia. This triangle is palpated with the knee in 90deg of flexion before the joint is distended. The structures in the posteromedial compartment can be visualised via a 30deg angled arthroscope inserted through this portal. The location of this portal is 1cm superior to the posteromedial joint line and 1cm posterior to the posteromedial margin of the femoral condyle. This part is mainly used for dealing with pathologies of the posterior horn

of the menisci and posterior loose bodies that cannot be approached through the anterior portals.

Superolateral portal

This is mainly used for visualisation of the dynamics of the patellofemoral joint such as patellar tracking, patellar congruity when the knee is moved from extension to flexion. The location of this portal is 2.5cm above the superolateral border of the patella and lateral to the quadriceps tendon.

Optional portals:

The optional portals include

1) Posterolateral portal

2) Proximal midpatellar lateral and medial portals

3) Accessory far medial and lateral portal

4) Central transpatellar tendon (Gillquist) portal

Examination under anaesthesia and patient positioning:

All the patients in our study were operated under spinal anaesthesia in supine position. The following tests were done under anaesthesia – anterior drawer test, posterior drawer test, Lachman test and pivot shift

test. A pneumatic tourniquet is applied which is positioned in the upper thigh after soft padding. The limb is scrubbed from the ankle upto the tourniquet. The patient is positioned supine and the knee joint is placed slightly away from the distal breakpoint of the standard operating table. The uninvolved limb is placed in a well-leg support. In all the cases, prophylactic antibiotic usually 1 g ceftriaxone is given pre operatively before inflation of the tourniquet. The limb is held upright to exsanguinate the limb before inflation of the tourniquet

Surgical technique:

The technique of single bundle ACL reconstruction was done with one tibial tunnel and one femoral tunnel with their centres corresponding to the centre of the native ACL tibial and femoral attachment sites respectively. The femoral tunnel was made using the anteromedial portal thereby creating an anatomic femoral tunnel position.

The graft was fixed at the tibial side using bioscrew / titanium interference screw or endobutton and at the femoral side using endobutton.

Diagnostic Arthroscopy:

Before the harvesting of graft, diagnostic arthroscopy was done first. In 90 degrees of knee flexion, anterolateral port (viewing portal) is

made using 11 blade at the level of inferior pole of patella just lateral to the patellar tendon. Then the scope is introduced and knee is examined in a sequential manner of the following:

- Suprapatellar pouch
- Patellofemoral joint
- Medial gutter
- Medial meniscus
- Intercondylar notch
- Lateral meniscus
- Lateral gutter
- Posterolateral compartment

After all the pathologies have been recorded, the anteromedial (working) portal is then established. The associated pathologies are dealt accordingly such as partial / total meniscectomy for meniscal tears and loose body removal.

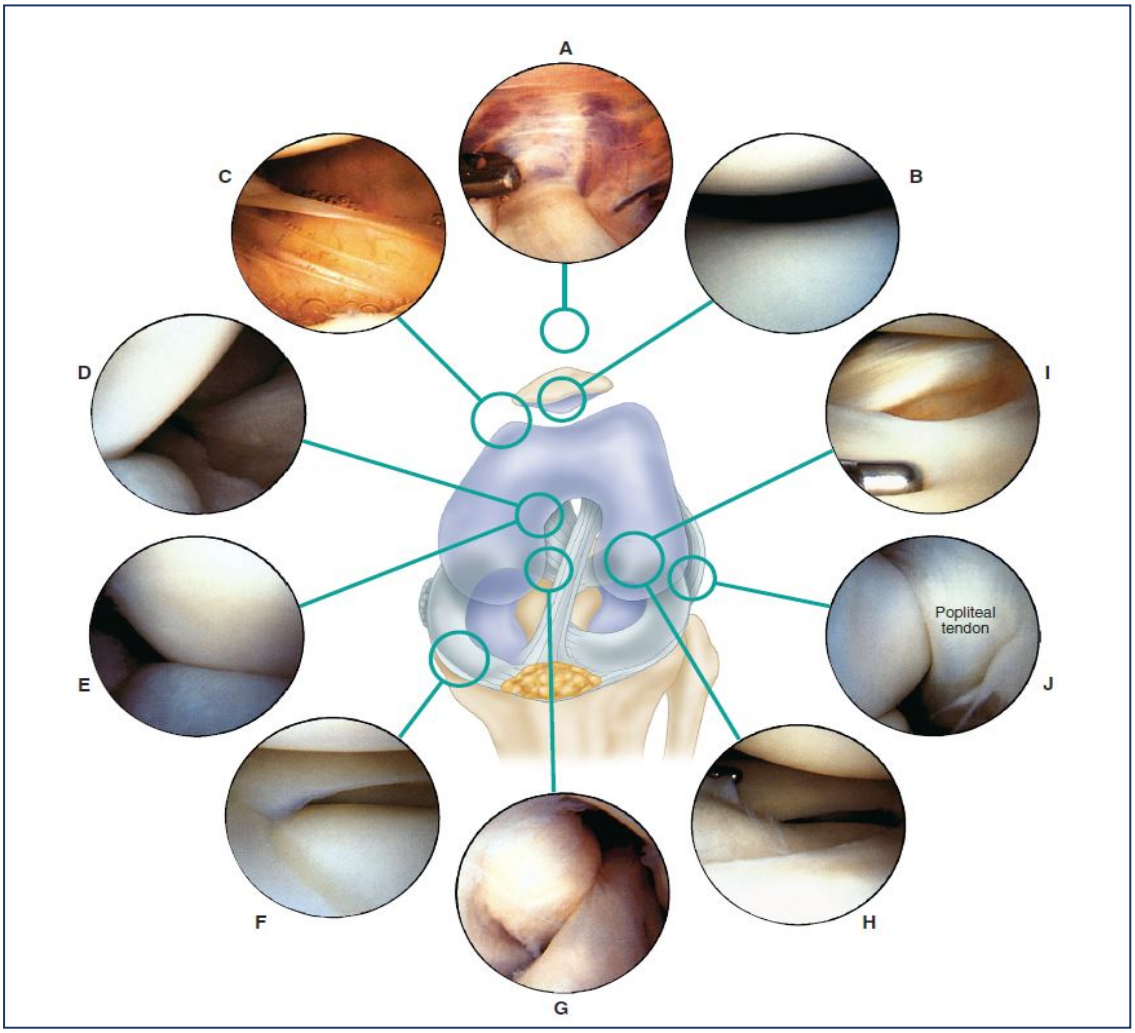


Fig 20: Showing various structure of knee when viewed arthroscopically through various portals during diagnostic arthroscopy

A. Suprepatellar pouch
B. Patellofemoral articulation
C. Normal medial parapatellar plica
D. Posteromedial compartment
E. Posteromedial compartment when seen through posteromedial portal, which is made after completion of routine examination if complete posteromedial view is unsatisfactory
F. Medial meniscus and medial compartment
G. Cruciate ligament with fatty synovium covering PCL
H. Lateral meniscus and lateral compartment
I. View of posterior horn of lateral meniscus and popliteal tendon through hiatus

Hamstring graft harvest and graft preparation:

A 3cm oblique skin incision is made starting 5 cm below the medial joint line and 1 cm medial to the tibial tuberosity. The oblique incision is preferred because it gives a wider exposure of pes anserinus and there is less chance of injury to the infrapatellar branch of the saphenous nerve. It is planned to do the graft harvest and tibial tunnel drilling through the same incision.

The superior border of the pes anserinus is identified using the fingers. This superior border is lifted and fascia incised. The tendons can be felt with fingers running from above downwards. The lowest one felt is the semitendinosus tendon. After the hamstring tendons are identified, the sartorius fascia is divided along the course of the tendons (gracilis and semitendinosus), taking care to preserve the deep layer containing the Medial Collateral Ligament. With the help of right angled artery forceps, the gracilis and then the semitendinosus are hooked out. The tendon ends were tied with double loop knot to aid in traction.

The knee is placed in 90 degrees of flexion and proximal dissection of the tendons were done using blunt dissection by fingers till the musculotendinous junction thereby releasing adhesions and accessory bands, while continuous traction was being applied through the threads. The main band which connects the medial head of gastrocnemius is

usually cut with the help of scissors. It is confirmed that as the tendon is pulled distally, there should be no dimpling posteriorly over the gastrocnemius.

The distal end of the tendon is freed with the scissors. Then a tendon stripper is advanced over the tendon in line with it maintaining firm, steady and gentle pressure and at the same time applying traction by holding the threads. If there is any resistance felt, then the stripper is withdrawn, adhesions removed and again the stripper is advanced and tendon harvested. The gracilis is usually more muscular appearing than the semitendinosus. The harvested graft is then placed on Graftmaster board. The tendons are removed of any residual muscle fibres with the help of blunt end of the blade.

Fig 21: Skin incision for graft harvest

Fig 22: Exposure of tendon

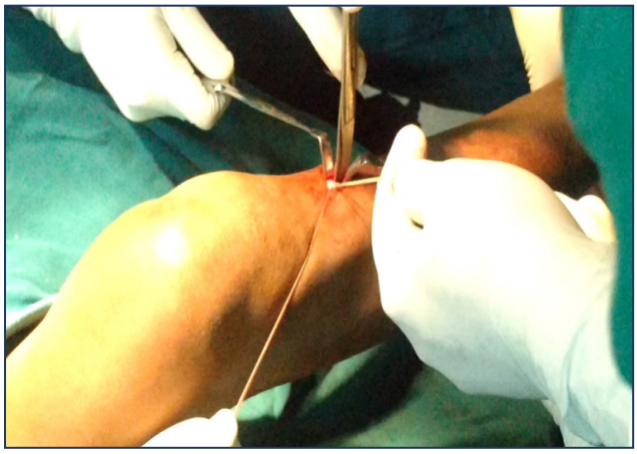


Fig 23: release of accessory bands

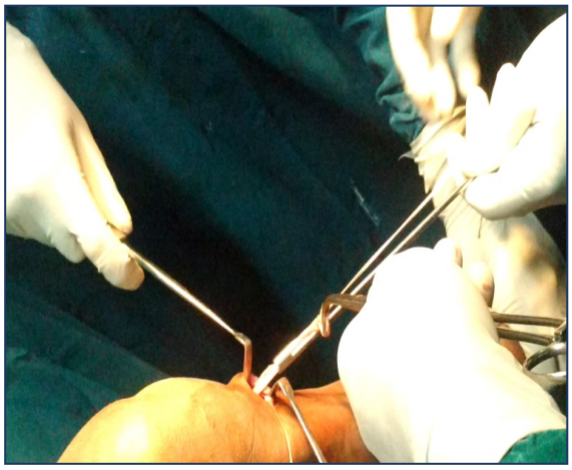


Fig 24: stripping of tendon using tendon stripper

The tendon ends are trimmed to achieve uniform size. A whipstitch is placed at both ends of the tendons. Around 3-4 cm of both the ends of the tendon were stitched together. The two tendons are looped over a umbilical tape. The composite graft is then passed through the graft sizer. The diameter of the tunnel to be made is equal to the smallest sizing sleeve through which the quadrupled graft passed with minimum friction.

The graft length to be placed inside the femoral tunnel is marked to ensure correct placement of graft within the femoral tunnel while being viewed arthroscopically.

The loop of the four strand graft is tied to the posts in the graftmaster board and pretensioning is done by applying a pressure of about 15 pounds for around fifteen minutes.

Fig 25: preparation of graft

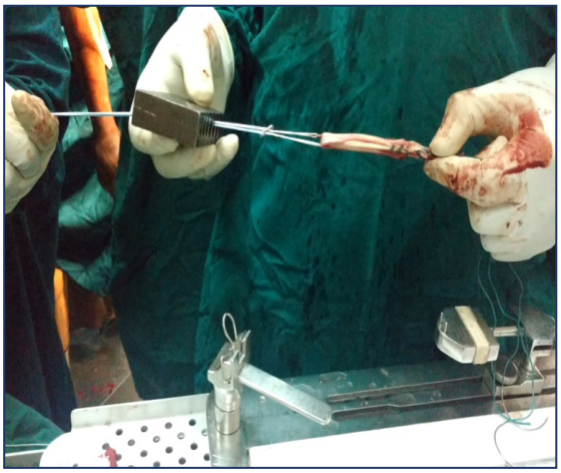


Fig 26: Sizing of the graft

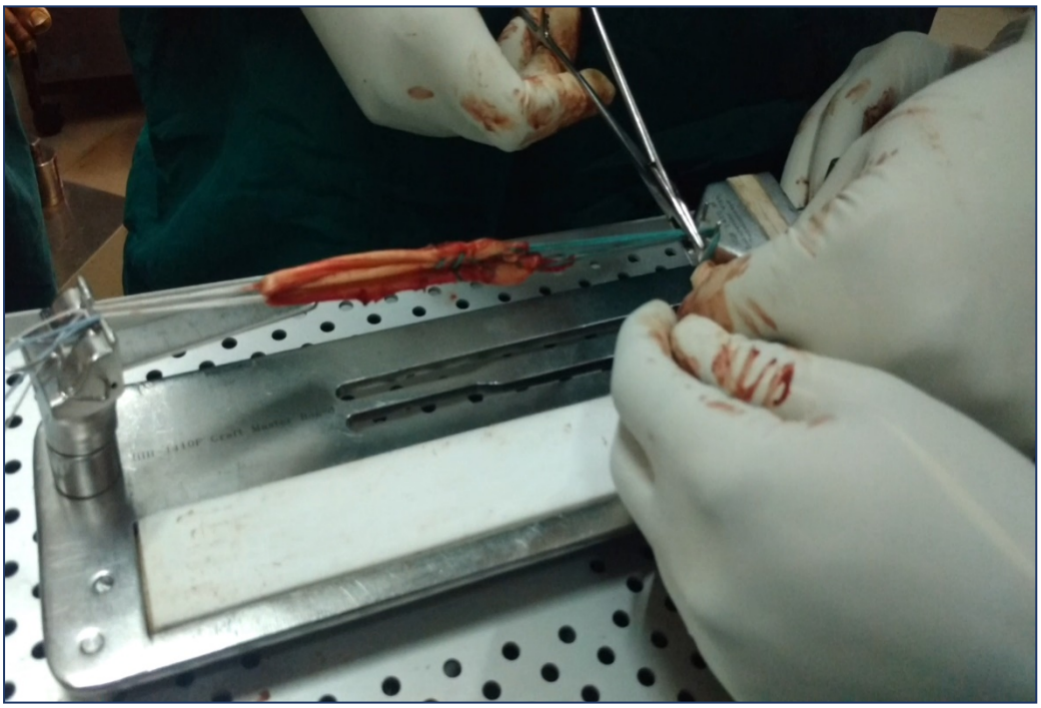


Fig 27: Pretensioning the graft

Intra-articular preparation:

The arthroscope was introduced via the anterolateral portal and joint cavity visulaised. The shaver blade is inserted through the anteromedial portal and the joint is debrided of ligamentum plicae, fat pads and synovial reflections that hinder a thorough inspection of the tibial footprint of the ACL and medial surface of the lateral femoral condyle. During the joint debridement, care should be taken to avoid injury to the intact PCL.

Notch preparation and Notchplasty:

Then the visualisation of the intercondylar notch is done. The torn ACL may be viewed as a stump scarred to the PCL or the roof of the

intercondylar notch or it may not extend till its attachment on the medial surface of the lateral condyle. (empty lateral wall sign). The residual ACL tissues are removed except the remnants on the tibial and femoral attachment sites. The femoral remnant will act as a landmark for the positioning of guide pins for making femoral tunnel while the tibial remnants may serve as neurologically active envelope for the graft, thereby having proprioceptive function after ACL reconstruction.

The careful shaping and enlargement of the intercondylar notch of the femur is called notchplasty. The objective of this is to gain adequate exposure of the medial surface of lateral femoral condyle and to prevent impingement of the graft against the roof/lateral wall. It is also important in cases of chronic ACL insufficiency in which osteophytes encroach into the notch.

Technique of Notchplasty:

The notch is usually deepened by 2 – 3 cm starting anteriorly on the articular surface of the intercondylar notch 2 – 3 cm superior to the margin. The direction of deepening of the notch should be anterolateral.

It is also important to deepenthe anterior roof of the notch to avoid impingement of the graft in full knee extension. The anteromedial side of the notch is not deepened unless there is presence of osteophytes.

The notchplasty should be limited to the anterior intercondylar notch and to avoid excess lateral notchplasty so as to avoid lateralisation of the femoral graft attachment site.

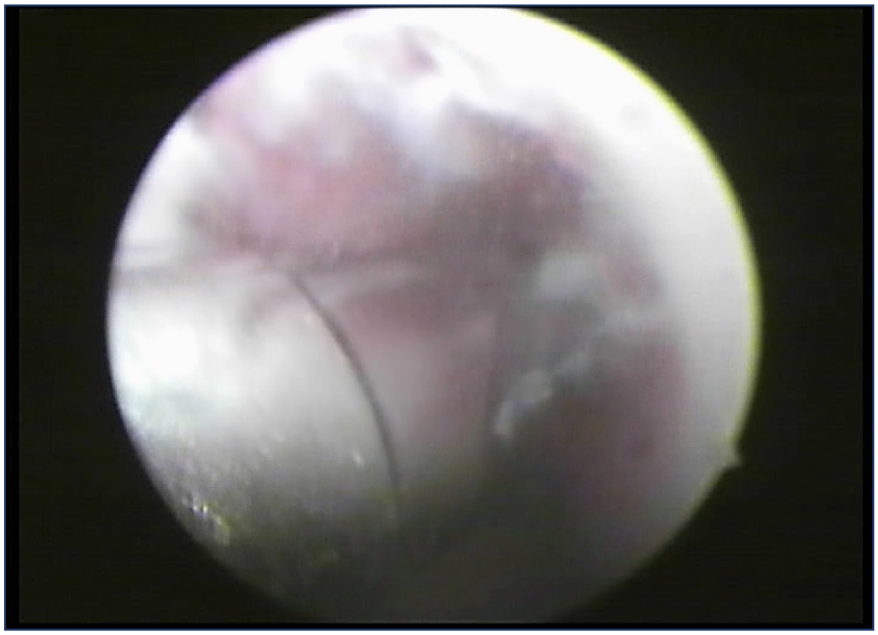


Fig 28: Notchplasty

Femoral tunnel preparation:

The ACL footprint is visualised on the medial surface of the lateral femoral condyle in 90 degrees of knee flexion and the entry point is marked. Then with the femoral offset aimer device inserted through the anteromedial port, the entry point is drilled with a guide wire in 120 degrees of knee flexion. The drilling is continued till the tip of the guide wire emerges on the lateral side of the distal thigh at the level of epicondyle of femur.

Then using the 4.5 mm cannulated drill bit, the femoral tunnel was made by drilling both the near and far cortices. Then the length of the tunnel was measured using a depth guage. Then the femoral tunnel was reamed with a reamer corresponding to the diameter of the graft. The reaming was stopped 15 – 20 mm from the lateral cortex depending on the length of the graft. After the femoral tunnel is made, the beath pin with ethibond at its end was passed via the femoral tunnel to aid in easy passage of prepared graft.

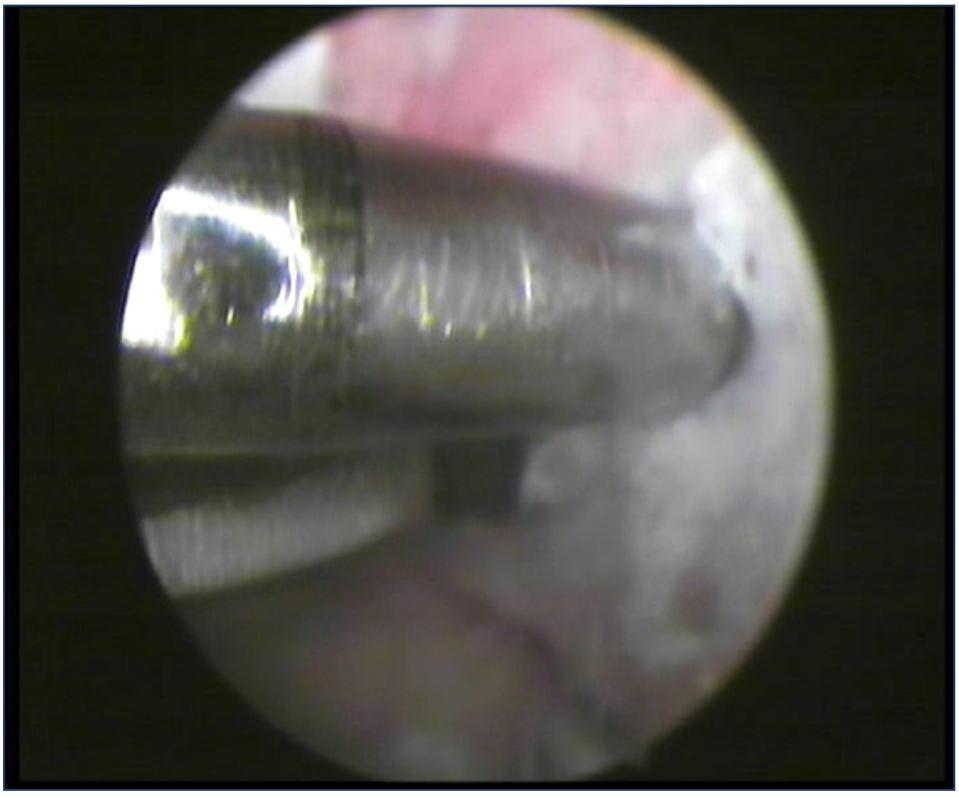


Fig 29: Femoral aimer at site of ACL footprint

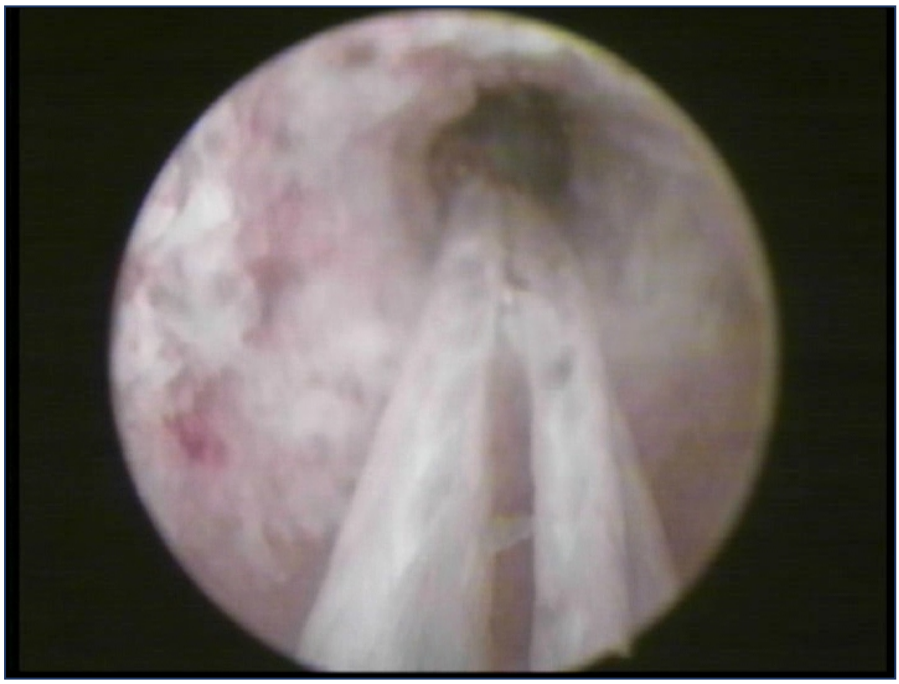


Fig 30: Femoral tunnel after reaming

Tibial tunnel preparation:

The tibial tunnel is made with the help of the tibial guide. With the knee in 70 – 90 degrees of knee flexion, the tip of of the tibial guide is placed 2 – 3mm anterior to the (posterior margin of) anterior horn of lateral meniscus and slightly medial to the midline of the ACL tibial attachment area. Then the tibial tunnel is made by reaming over the guide pin using cannulated drill bit with diameter equal to the diameter of the graft. The edges of the tunnel are smoothened using shaver leaving the remnants at the site of ACL tibial attachment site for better proprioception.

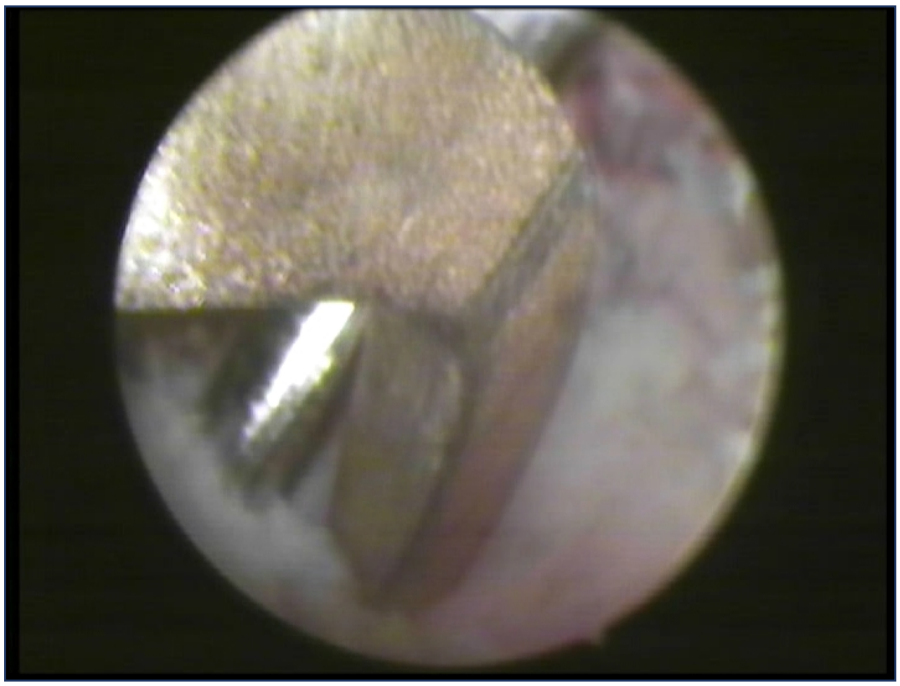


Fig 31: Tibial aimer device

Graft preparation, passage and fixation:

After the graft had been prepared, based on the length, the graft is quadrupled, the loop part of the quadrupled graft is attached to the endobutton with loop (the length of the loop in the endobutton depends on the graft length and the length of the unreamed femoral tunnel). The Ethibond suture already present within the joint is pulled out through tibial tunnel. Then the passing sutures for the ACL graft are passed through the suture loop and are taken out of the lateral thigh. With the help of these sutures, the graft is pulled via the tibial tunnel into the joint and then into the femoral tunnel. Once the estimated length of the graft is within the the tunnel, the endobutton is flipped.

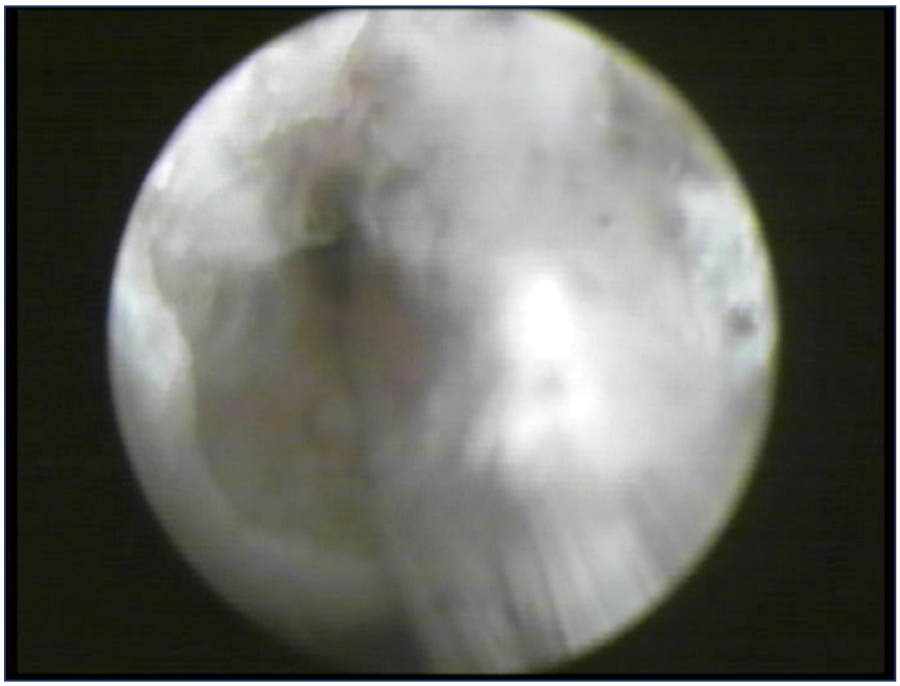


Fig 32: Graft being pulled into the femoral tunnel

Then cyclical tensioning of the graft is done by repeated knee flexion and extension (around 20 – 30 times) with sustained pull on the graft via the tibial tunnel. Then the arthroscopic visualisation of the graft is done to look for any signs of graft impingement, alignment, etc. The tibial side of the graft is fixed with interference screw (titanium or bioscrew) of appropriate length.

The ports and the graft harvest site wound are closed in layers. Sterile compressive dressing is then applied. The limb is immobilised with the use of knee brace.

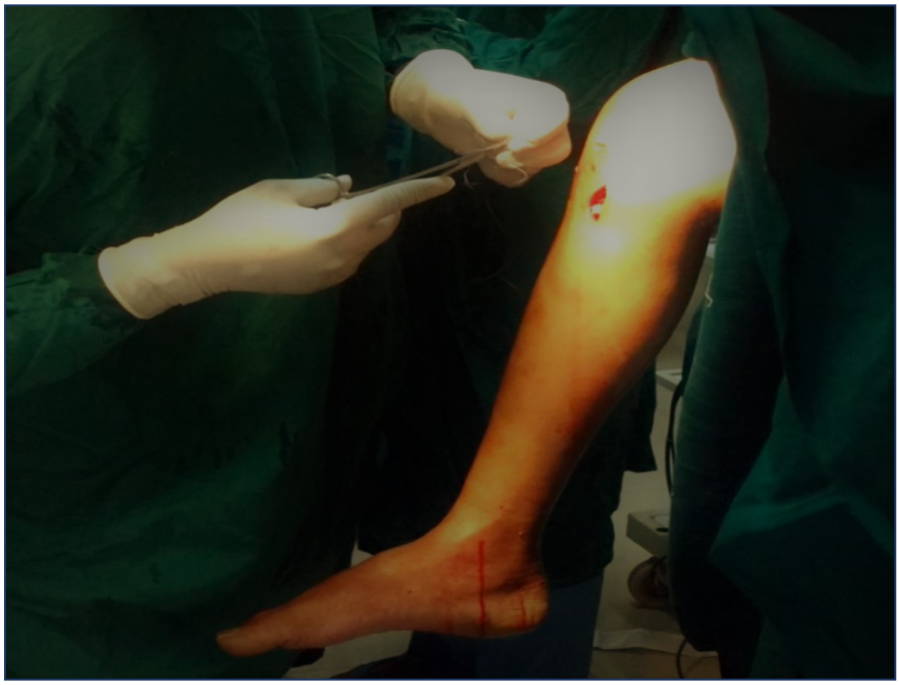


Fig 33: Wound Closure

Post-operative management:

Immobilisation in knee brace and limb elevation was done in the immediate post op period. Intravenous antibiotics were given post-operatively for 3 days. Wound was inspected on 2nd post-operative day. Wound was inspected on 2nd, 7th post-operative day. The sutures were removed on 12th post-operative day. Rehabilitation was started from day one.

ACL Rehabilitation protocol:

Stage I: 0 to 2 weeks

- Patella mobilization
- Motion control brace 0 to 90 degrees

- Quadriceps sets/ straight leg raising in all planes (emphasize SLR without extension lag)
- Prone / standing hamstring curls
- Passive extension (emphasize full extension)
- Prone hangs
- Pillow under heel
- Passive, active and active assisted ROM knee flexion
- Wall slide
- Sitting slide
- Partial weight bearing 50 to 75% with crutches or weight bearing to tolerance without crutches if Motion control brace locked in full extension
- Sleep in brace locked in full extension

Goals:

- Full knee extension
- 90 degree knee flexion
- Good quadriceps strength
- Emphasize normal gait

Stage II: 2 to 4 weeks

- Motion control brace – full range of motion
- Progress ROM to 120 degree by fourth week

- Progress SLR and prone / standing hamstring curls with weights
- Full weight bearing with crutches and discontinue crutches when ambulating without limp
- Wall sits at 45 degrees angle with tibia vertical, progress time
- Knee extension 90 to 60 degrees with manual resistance by therapist

Goals:

- Range of motion – 0 to 120 degrees
- Full weight bearing with crutches and no limp

Stage II: 4 to 10 weeks

- Progress to full ROM by 6 weeks
- Begin lunges
- Continue strengthening of lower extremity muscle groups , especially through full range of hamstring/ quadriceps

Stage III: 12 to 16 weeks

- Continue flexibility exercises
- Quadriceps strength progression
- Sports specific cardiovascular fitness

Stage IV: 16 to 18 weeks

- Begin plyometric program with shuttle, minitrampoline if quadriceps strength 65%, no effusion, full range of motion, stable knee
- Begin jogging program if quadriceps strength 65%

Stage V: 5 to 6 months

- Sports specific drills
- Agility training

Stage VI: 6 months

Return to sport if

- Motion >130 degrees
- Hamstring > 90 %
- Quadriceps > 85%
- Sports specific agility training completed

Evaluation:

All patients were subjected to post operative anteroposterior and lateral radiographs to determine the tunnel placement and position of endobutton and interference screw. Patients were followed at 6 weeks, 6 months and 1 year and functional outcomes assessed.

The International Knee Documentation 2000 score(IKDC) and Lysholm and Gillquist Knee Scoring Scale were used for evaluation of patients.

The Subjective IKDC scale was evaluated by summing the scores for the individual items and then transforming the score to a scale that ranges from 0 to 100. To calculate the final subjective IKDC score simply add the score of each item and divide by the maximum possible score which was 87.

Subjective IKDC score = [Sum of items/Maximum possible score] × 100

The score is interpreted as a measure of function such that higher scores represent higher levels of function and lower levels of symptoms. A score of 100 is interpreted to mean no limitation with activities of daily living or sports activities and the absence of symptoms.

The **Lysholm and Gillquist Knee Scoring** Scale consists of eight parameters for evaluation. The parameters evaluated are

1. Limping
2. Aided walking
3. Episodes of knee locking
4. Knee instability
5. Knee pain
6. Knee swelling
7. Climbing of stairs
8. Squatting

The individual parameters were allotted specific scores depending on the patient's functional ability. The maximum possible knee score was 100. Based on the outcome scores they were divided into Excellent, Good, Fair and Poor.

- Excellent – 95 – 100
- Good – 84 – 94
- Fair – 65 – 83
- Poor – 64 or less

The IKDC knee score and Lysholm knee score forms are attached as annexure I and II respectively.

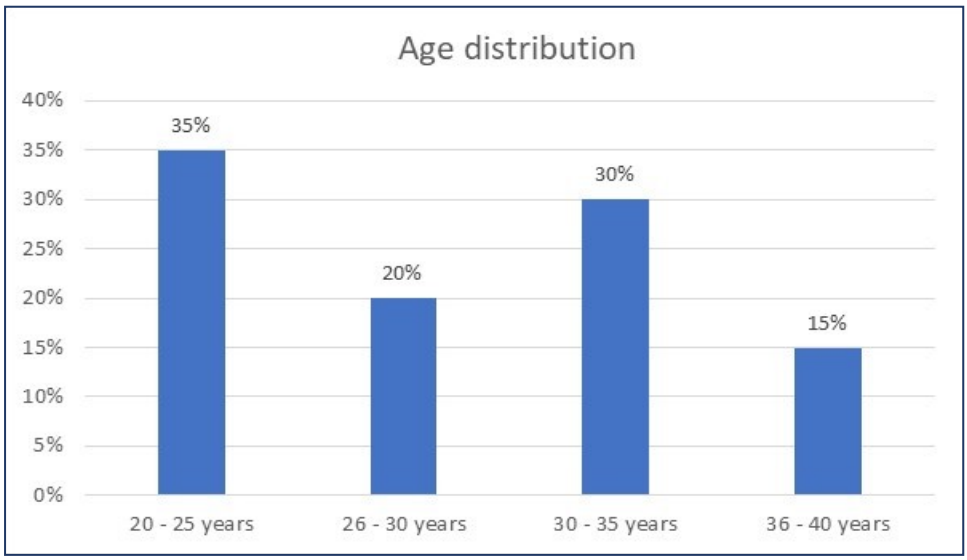
RESULTS

Twenty cases of arthroscopic ACL reconstruction were regularly followed for an average period of 17.6 months in Coimbatore Medical College, Coimbatore (from June 2015 to September 2017).

Age Distribution:

Table 1: Age distribution

Age(years)	Patients	percentage
20 - 25 years	7	35%
26 - 30 years	4	20%
30 - 35 years	6	30%
36 - 40 years	3	15%
	20	100%

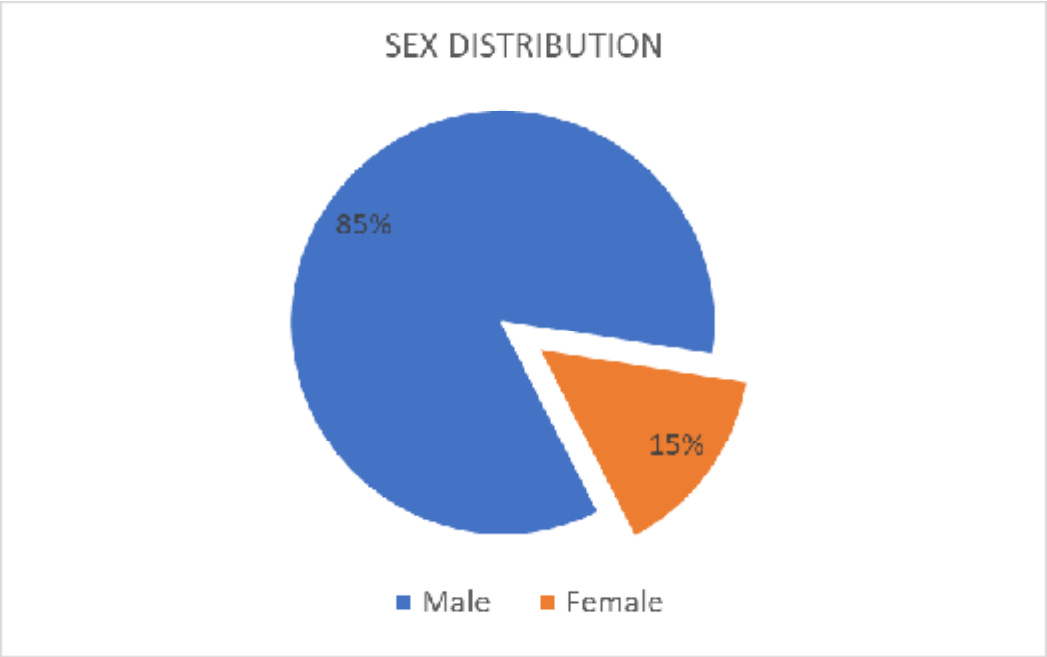


Most of the patients (35%) were in the age group of 20 to 25 years followed by 30% in the age group of 30 to 35 years.

Sex Distribution:

Table 2: Sex distribution

Gender	**Number of patients**	**percentage**
Male	17	85%
Female	3	15%
	20	100

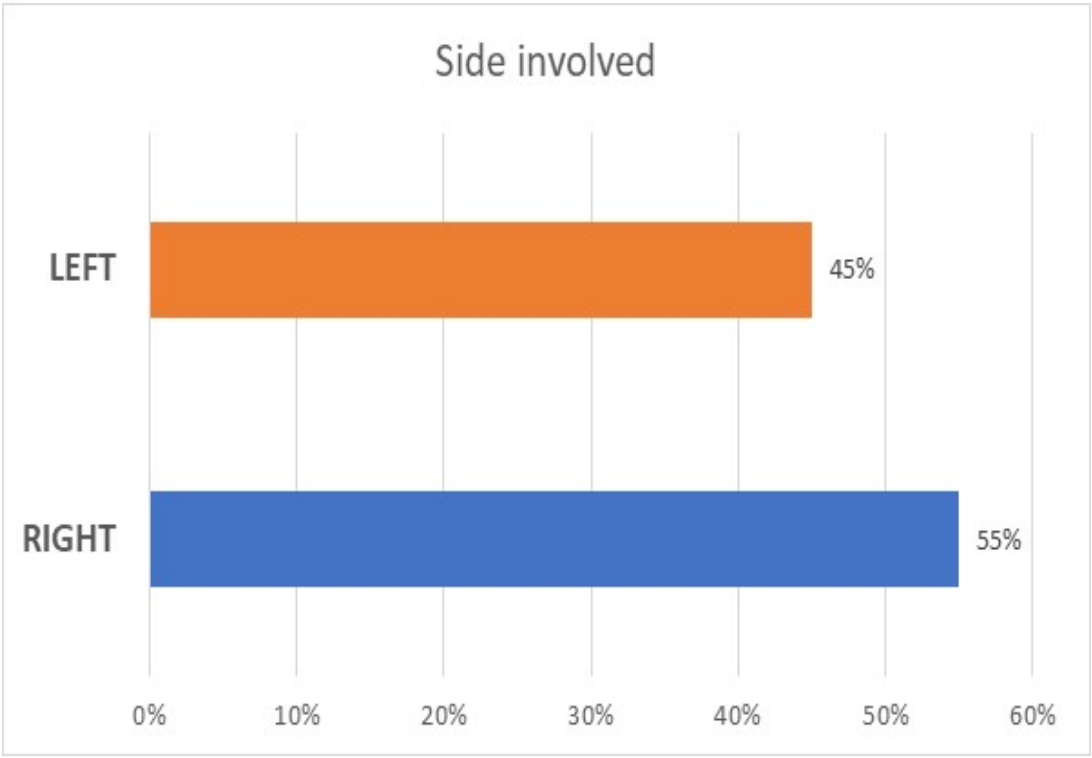


Of the 20 patients included in our study, 17 (85%) were Male patients and 3 (15%) were female.

Side involvement:

Table 3: Side involvement

SIDE	NUMBER OF PATIENTS	PERCENTAGE
RIGHT	11	55%
LEFT	9	45%
TOTAL	20	100%

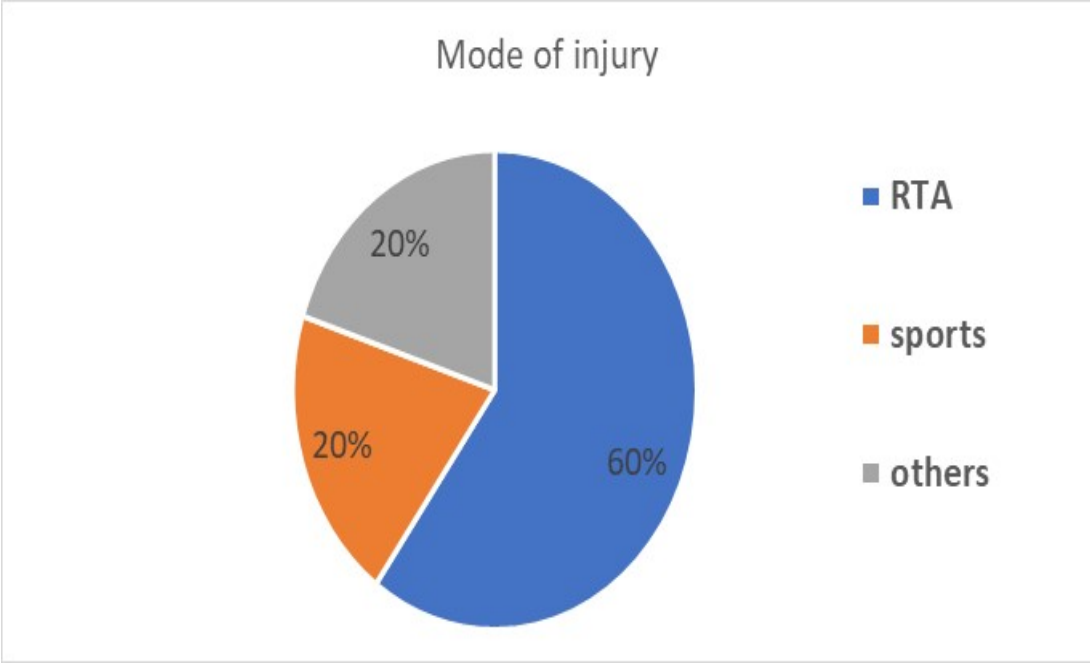


In this study, the right side was more commonly injured (55%) than the left side (45%)

Mode of Injury:

Table 4: Mode of Injury

MODE OF INJURY	NUMBER OF PATIENTS	PERCENTAGE
RTA	12	60%
sports	4	20%
others	4	20%
	20	100%

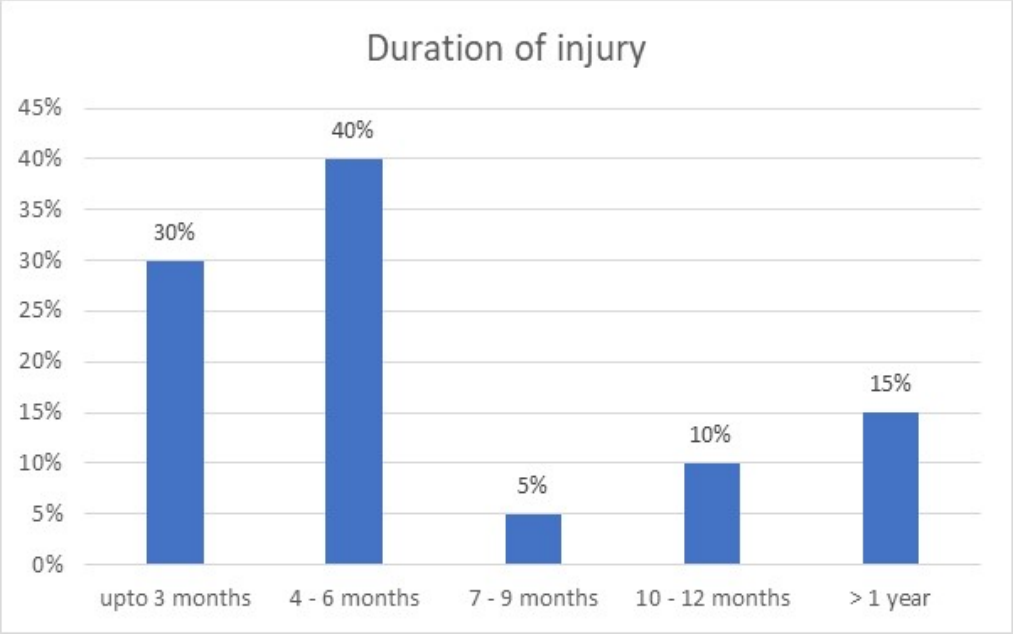


The most common mode of injury in our study was Road Traffic Accidents (60%) followed by sports (20%). The other modes of injury in our study were self fall and kick by bull.

Injury Surgery Interval:

Table 5: Duration between injury and surgery

Duration	Patients	Percentage
up to 3 months	6	30%
4 - 6 months	8	40%
7 - 9 months	1	5%
10 - 12 months	2	10%

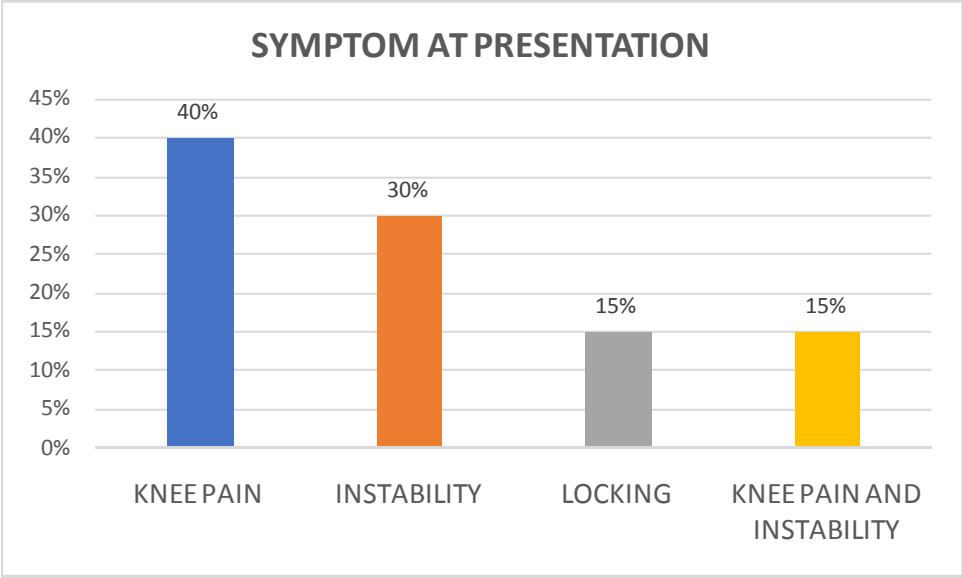


In our study, most of the patients (40%) presented 4 to 6 months after injury.

Symptom at presentation:

Table 6: Symptom at presentation

SYMPTOM AT PRESENTATION	NO. OF PATIENTS	PERCENTAGE
knee pain	8	40%
instability	6	30%
locking	3	15%
knee pain and instability	3	15%
	20	100%

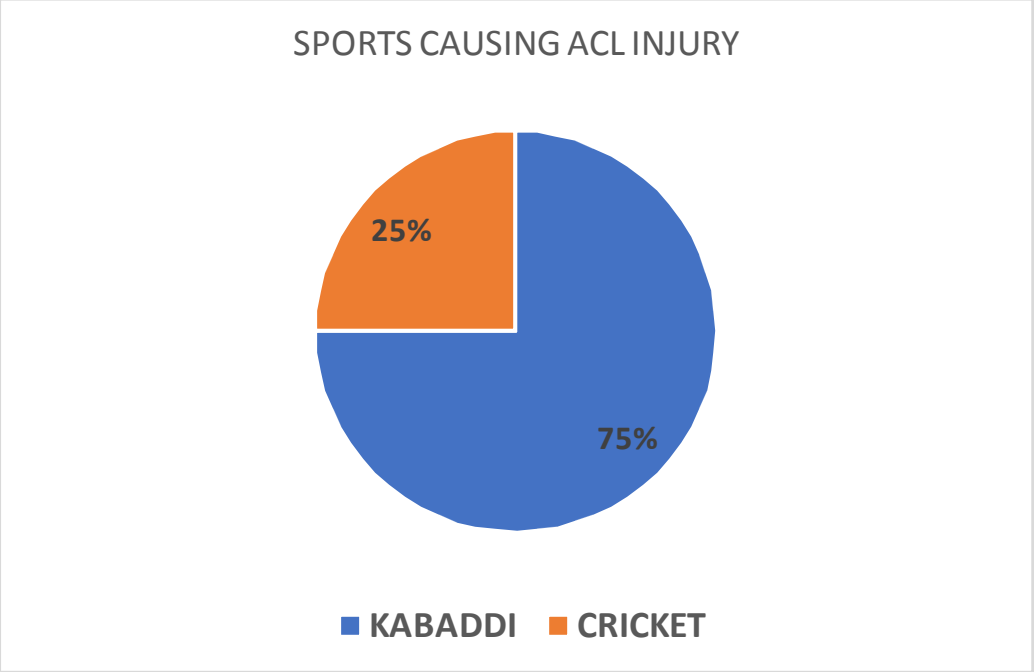


The most common symptom at presentation was knee pain (40%) followed by instability (30%). Both knee pain and instability were present in 15% of patients.

Sports causing ACL injury:

Table 7: Sports causing ACL injury

SPORTS	NUMBER OF PATIENTS	PERCENTAGE
Kabaddi	3	75%
cricket	1	25%

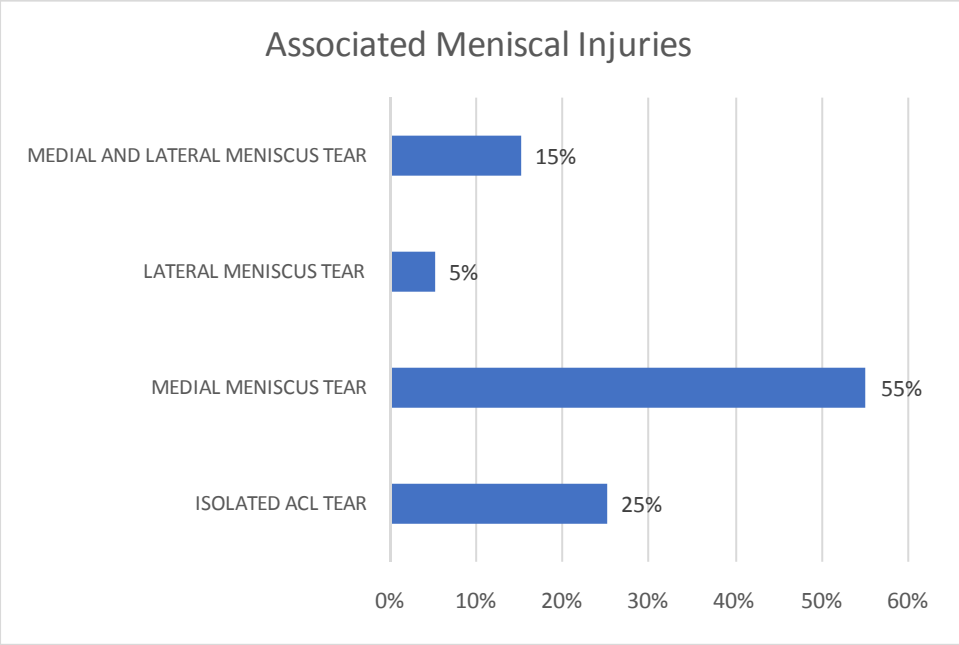


In this study, Kabaddi was the most common sport causing injury to the Anterior Cruciate Ligament.

Associated Meniscal injuries:

Table 8: Associated Meniscal injuries

S.No	Associated injuries	No. of cases	Percentage
1	Isolated ACL tear	5	25%
2	medial meniscus tear	11	55%
3	lateral meniscus tear	1	5%
4	medial and lateral meniscus tear	3	15%

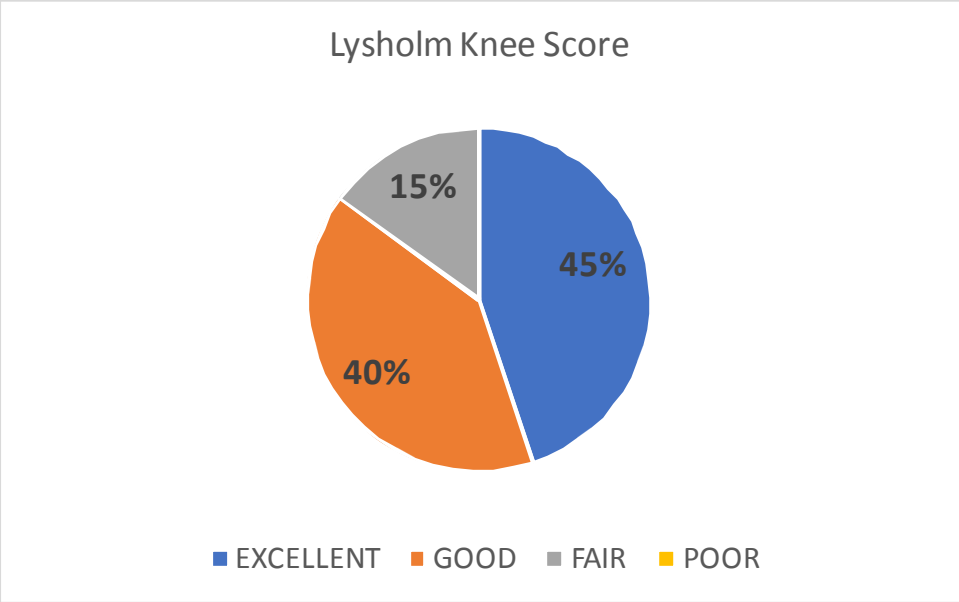


In our study, there was associated meniscal injury in 75 % of patients. The most commonly injured was medial meniscus (55%) followed by injury to both medial and lateral menisci (15%). Isolated ACL tear was present in 5 patients (25%).

Lysholm Knee Score:

Table 9: Lysholm Knee score

S.NO	RESULTS	NO. OF CASES	PERCENTAGE
1	Excellent	9	45%
2	Good	8	40%
3	Fair	3	15%
4	Poor	0	0



9 patients (45%) had excellent functional outcome while 8 patients (40%) had good outcome. The remaining 3 patients (15%) had a fair outcome according to Lysholm knee score.

IKDC Subjective score:

Table 10: IKDC subjective score

	Preop Mean (standard deviation)	**Post op Mean (standard deviation**	**P value**
IKDC subjective score	50.86 (10.45)	87.66 (6.98)	0.00001

The mean pre-op IKDC subjective score was 50.86 while the mean post op score was 87.66. There was significant improvement in post op IKDC score when compared with pre op score ($p<0.05$).

Complications:

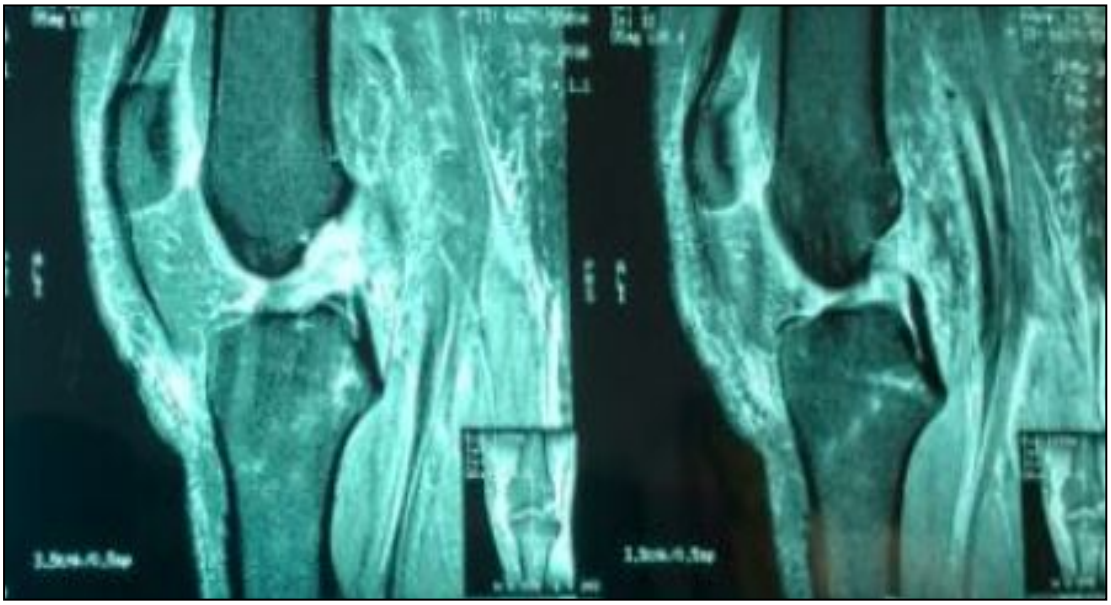
1. One patient in our study had superficial infection at the donor site which settled with intravenous antibiotics.

2. One patient developed deep infection of the donor site with gaping of the wound. The patient underwent wound debridement and secondary closure and was given intravenous antibiotics. The wound healed well and sutures were removed after 10 days.

3. One patient developed fixed flexion deformity of 10 degrees with range of movements ranging from 10 to 90 degrees. The patient had poor compliance to the rehabilitation protocol.

CASE ILLUSTRATIONS

Case 1



Pre op MRI showing ACL tear with intact PCL in sagittal section

Post op X – ray showing endobutton used for graft fixation on the tibial and femoral sides

Clinical picture Showing full range of knee movement without extension lag at 18 months follow up

Clinical picture Showing the patient's ability to squat without difficulty

Case 2

Pre op MRI showing ACL deficient knee in sagittal section

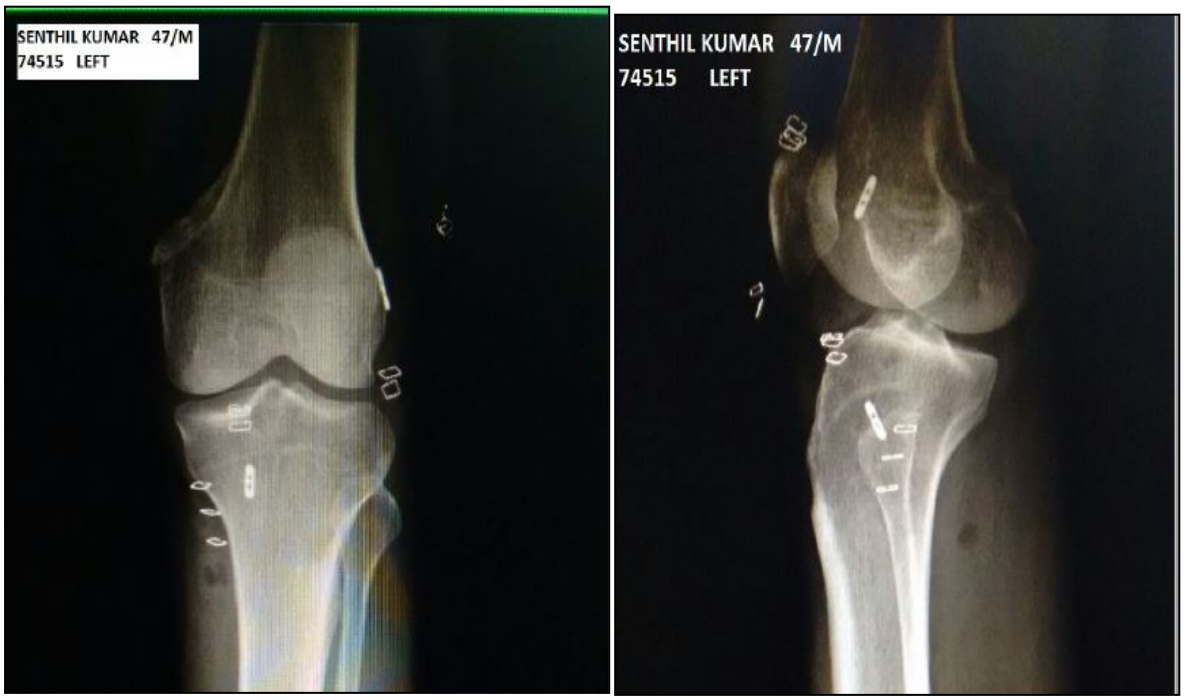
Post op X – ray showing endobutton used for graft fixation on femoral side and interference screw on tibial side

Clinical picture showing painless full range of knee movements without extension lag at 1 year follow up

Clinical picture showing the patient's ability to sit cross legged without difficulty

Case 3

Pre op MRI showing ACL tear with intact PCL in the sagittal section



Post op X – ray showing endobutton used for graft fixation on the tibial and femoral sides

Case 4

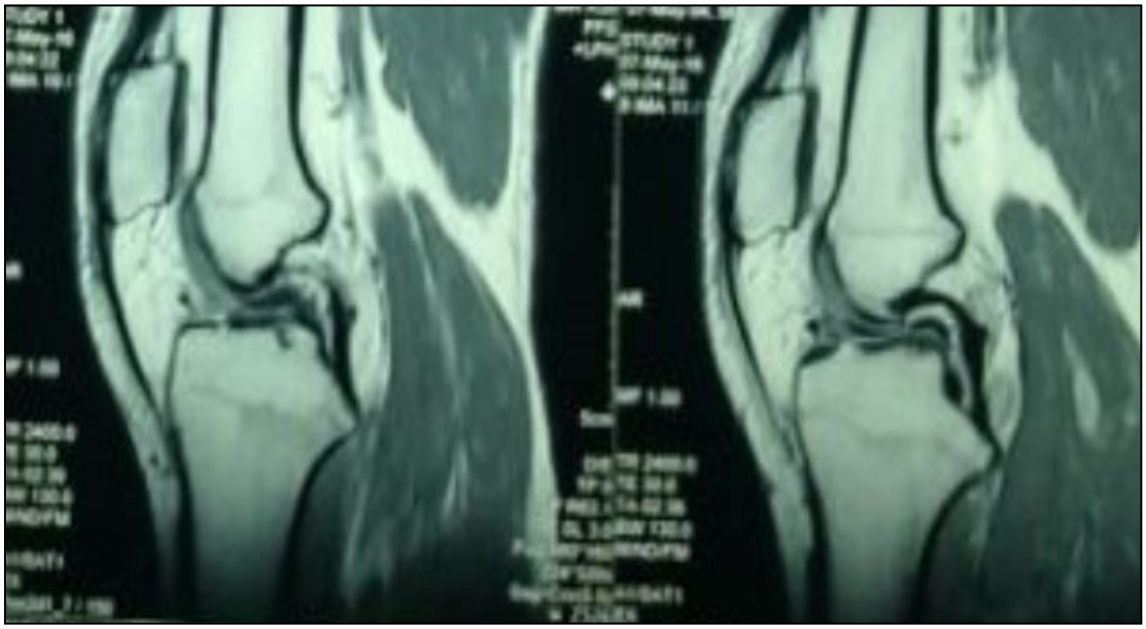
Pre op MRI showing ACL tear with intact PCL in sagittal section

Post op X – ray showing endobutton used for graft fixation on the tibial and femoral sides

Clinical picture Showing the patient's ability to squat without difficulty

Clinical picture showing the patient's ability to sit cross legged without difficulty

Case 5

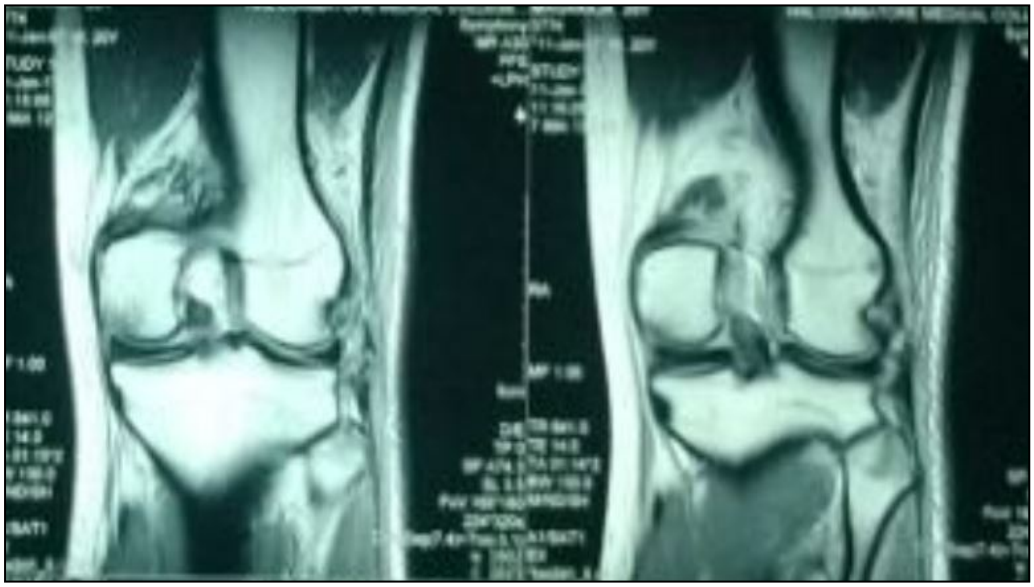


Pre op MRI showing torn ACL with intact PCL

Post op X – ray showing endobutton used for graft fixation on the femoral side, bioscrew had been used for fixation on tibial side

Clinical picture showing painless full range of knee movements compared with the contralateral knee at 6 months follow up

Case 6



Pre op MRI showing ACL tear with intact PCL in the coronal section

Post op X – ray showing endobutton used for graft fixation on the femoral side and interference screw on tibial side

Clinical picture Showing painless full range of knee movements without extension lag at 16 months follow up

Clinical picture showing the patient's ability to squat without difficulty

DISCUSSION

Due to the increased occurrence of Road Traffic Accidents and increased number of persons participating in sports activities, the number of ACL reconstructions being done has been increased. Arthroscopic reconstruction of the injured ACL has become the gold standard and is one of the most common procedures done in orthopaedics and thus it has been extensively studied and outcomes of ACL reconstruction have gained considerable attention.

The choice of graft is a topic of great debate in recent years. The various options include bone patellar tendon bone graft, hamstring auto-graft, quadriceps tendon, various synthetic grafts and allograft.

Among these, the most commonly used are the Bone patellar tendon bone graft and hamstring graft. The advantages of Bone patellar tendon bone graft include high ultimate tensile load (approximately 2300 N) and a rigid fixation due to its bony ends.

But the hamstring graft has been increasingly used in recent. The advantages of arthroscopic ACL reconstruction using hamstring graft include decreased surgical site morbidity, decreased occurrence of patellofemoral adhesions and reduced incidence of anterior knee pain. Though the semitendinosus tendon has only 75% and gracilis 49% of the

strength of native ACL, the quadrupled semitendinosus or semitendinosus-gracilis have a tensile load of around 4108 N.

Our study is to evaluate the functional outcome of arthroscopic anatomical single bundle ACL reconstruction using quadrupled hamstring autograft.

This prospective study was conducted in Coimbatore Medical College and Hospital, Coimbatore to clinically evaluate the clinical results of arthroscopic single bundle ACL reconstruction. This study group comprised of 21 patients with one patient lost to follow up.

In our study, the most common mode of injury was Road Traffic Accident followed by Sports injuries. One of the patients had an injury due to kick by a bull. Among the sports injuries, Kabaddi was the most common cause of ACL tear. Male predominance was found in our study. 17 (85%) patients were males and 3 (15%) were females. Most of the patients were in the age group of 20 – 25 years (35%). 40% of patients (n=8) underwent ACL reconstruction 4 to 6 months after injury.

The Right knee was involved in 11 (55%) of patients and left knee in 9 (45%) patients. There was not much difference in lateralisation of injury.

D.W Lewis et al.[57], in their study on incidence of meniscal injuries at the time of ACL reconstruction found that 58% of patients had meniscal injuries and that medial meniscus was most commonly injured. They also concluded that meniscal repair or resection did not alter the final outcome.

In our study, there was associated meniscal injury in 75 % of patients. Five patients in our study had isolated ACL injury. Eleven patients had injury to the medial meniscus whereas one patient had injury to the lateral meniscus alone. Three patients had injury to both the medial and lateral meniscus. The most commonly injured was medial meniscus which was in accordance with other studies.

Among the patients with meniscal injuries, three patients were treated by partial meniscectomy and in one patient meniscal repair was done. The rest of the patients were treated conservatively. The functional outcome of patients with isolated ACL injury was comparable with that of the patients with associated meniscal injuries. This is in accordance with the study by D.W Lewis et al who stated that the presence of meniscal injury does not alter the functional outcome.

The most common symptom at presentation was knee pain (40% of patients). The other presenting symptoms were instability (30%), locking (15%) and 15% patients presented with both pain and instability.

The results of the study were compared with the studies of D Choudhary et al. 2005[58], Jomha et al. 1999[59], Riley et al. 2004[60], Mahir et al. 2005[61] and Ashok Kumar et al.2016[62].

Average age of patients at the time of surgery in the present study was 29 years whereas that of Johma et., D Choudhary et al, Railey et al., Mahir et al and Kumar et al.were 26, 27, 33, 24 and 27 years respectively.

Table 11: Patient variables in various studies

Study	Graft Used	No. of Patients	Mean age at Surgery	Mean Follow up Interval (months)	Gender
D Choudhary et al.	Ipsilateral autogenous BPTB	59	26 Years	84	73% Male
Jomha et al.	Ipsilateral autogenous BPTB	100	27 Years	12	93% Male
Railey et al.	Four stranded Hamstring graft	85	33 Years	24	59% Male
Mahir et al.	Four stranded hamstring graft	62	24 Years	18	100% Male
Ashok Kumar et al.	Ipsilateral autogenous BPTB four stranded hamstring graft	34 (12;22)	27years	14	97.1% Male
This study	Four stranded Hamstring graft	20	29 years	17	85 % Male

Average duration of follow-up of the present study was 17 months with a minimum follow-up period 7 months and maximum follow-up period was 27 months. Average duration of follow-up of D Choudhary et al. was 12 months and that of Jomha et al. was 84 months, Railey et al. was 24 months, Mahir et al. was 18 months and Ashok Kumar et al.2016 was 17 months.

The average Lysholm score at the end of the study of D Choudhary et al. was 92, Jomha et al. was 94, Railey et al. was 91, Mahir et al. was 93.5, Ashok Kumar et al.2016 was 90 and in our study average Lysholm score at last followup was 91.9 which was comparable with the above studies.

Table 12: Lysholm Knee Score

Study	**Average Lysholm Score**
D Choudhary et al. 2005	92
Jomha 1999	94
Railey et al. 2004	91
Mahir et al. 2005	93.5
Ashok Kumar et al.2016	90
Present study	91.9

From the above studies, it can be seen that the functional outcome after ACL reconstruction with hamstring graft and bone patellar tendon bone graft are comparable.

The mean pre-operative IKDC score in this study was 50.86 whereas the post-operative score was 87.66. There was significant improvement in post-operative IKDC score when compared with pre-operative score.

The mean pre-operative IKDC score in the study by Kumar et al. was 55.63, Prasad et al.[63] was 42.45 and Aparajit et al.[64] was 50.5 whereas the post-operative scores were 89.38, 94.33 and 86.03, respectively.

Table 13: IKDC Knee Score

Study	**Pre- op IKDC Score**	**Post- op IKDC Score**
Kumar et al.	55.63	89.38
Prasad et al.	42.45	94.33
Aparajit et al.	50.5	86.03
This study	50.86	87.66

From the above data, it can be seen that the post-operative IKDC score in this study was comparable with the scores from other studies.

There was no significant patellofemoral pain noticed in the patients in our study. This is similar to the study by Railey et al. who did not observe any clinically relevant patellofemoral pain in patients in whom arthroscopic ACL reconstruction using hamstring graft was done.

Agiletti et al.[65] in their study, found >5 mm tibial translation in 20% of kneesin which the torn ACL was reconstructed with hamstring graft. In our study, anterior tibial translation was eliminated in 85% of patients who were examined at a mean of 17 months post-operatively. The remaining 15% of patients (three) had a 1+ Lachman test at the follow up examination. However the laxity did not correlate with the functional scores.

Williams et at.[66] in their study of 2500 cases of arthroscopic ACL reconstruction, reported an infection rate of 0.3%. In our study, one patient had a deep infection and one patient had superficial infection. The patient with deep infection was managed with wound debridement and intravenous antibiotics while the patient with superficial infection was managed with antibiotics alone.

CONCLUSION

The summary of this prospective study is as follows:

- In young active adults, anatomic single bundle reconstruction with quadrupled hamstring graft gives good functional results
- The absence of patellofemoral pain with the use of hamstring graft makes it a more desirable option for patients with patellofemoral cartilage disorders or those with chronic patellofemoral pain
- Hamstring graft fixation with endobutton and interference screw gives good functional outcome
- Arthroscopic anterior cruciate ligament reconstruction with hamstring graft is an excellent treatment option for anterior cruciate ligament deficient knees.

Limitations of this study are

- Small sample size
- The results of the study were assessed using subjective scores and not based on objective assessment
- Short duration of follow-up

  Follow up studies of longer duration are required to assess the long term outcome of this procedure.

BIBLIOGRAPHY

1. David Simon, Randy Mascarenhas, Bryan M. Saltzman, Meaghan Rollins, Bernard R. Bach Jr., and Peter MacDonald, "The Relationship between Anterior Cruciate Ligament Injury and Osteoarthritis of the Knee," Advances in Orthopedics, vol. 2015, Article ID 928301, 11 pages, 2015. doi:10.1155/2015/928301.

2. Brophy RH, Zeltser D, Wright RW, Flanigan D. Anterior cruciate ligament reconstruction and concomitant articular cartilage injury: incidence and treatment. Arthroscopy. 2010;26:112–120

3. Galen C: On the usefulness of the parts of the body. Ithaca Cotnett University Press 1968.

4. Bonnet A - Traite Des Maladies Articulaires -2nd edition: Baillire, Paris.pp 1853; 354-357.

5. Stark J (1850) Two cases of rupture of the crucial ligament of the knee-joint. Edinb Med Surg 74:267–271.

6. Noulis G - Entorse du genou. These N° 142. Fac Med Paris 1875; 1-53.

7. Segond PF - Recherchescliniquesetexperimentales sur les epanchementssanguins du genou par entorse. Prog med 1879; 16: 297-421.

8. Mayo Robson AW - Ruptured cruciate ligaments and their repair by operation. Ann Surg 1903; 37: 716-718.

9. Hey Groves EW - Operation for the repair of cruciate ligament. Lancet 1917; 2:674-675.

10. Campbell WC - Repair of the ligaments of the knee: Report of an operation for the repair of the anterior cruciate ligament. SurgGynecolObstet 1936; 62: 964-968.

11. Macey HB - A new operative procedure for repair of ruptured cruciate ligament of the knee joint. *Surg. Gynecol - Obstet. 1939; 69:108-109.*

12. Jones KG - Reconstruction of the anterior cruciate ligament using the central one-third of the patellar ligament- a follow-up report. *J Bone Join Surg. 1970; 52A:1302-1308.*

13. Galway RD, Beaupre A, Macintosh DL - Pivot shift: a clinical sign of symptomatic anterior cruciate insufficiency. *J Bone Join Surg. (Br) 1972; 54B:763-764.*

14. Torg JS. Conrad W, Kalen V – Clinical diagnosis of anterior cruciate ligament instability in the athlete. *Am J Sports Med 1976; 4: 84-91.*

15. Rubin RM, Marshall JL, Wang J - Prevention of knee instability: exper-imental model for prosthetic anterior cruciate ligament. *ClinOrthop 1975; 113: 212-236.*

16. Lipscomb AB, Johnston RK, Snyder RB- Evaluation of hamstring strength following use of semitendinosus and gracilis tendons to recon-struct the anterior cruciate ligament. *Am J Sports Med 1982; 10:340-342*

17. Noves, Butler, Grood – Biomechanical analysis of human ligament grafts used in knee ligament repairs and reconstructions. *J Bone Joint Surg 1983, 66(A):344-352.*

18. Friedman MJ - Arthroscopic semitendinosus (gracilis) reconstruction for anterior cruciate ligament deficiency. *Techniques in Orthopaedics 1988; 2:74-80.*

19. Paulos LE, Cherf J, Rosenberg TD - Anterior cruciate ligament reconstruction with autograft. *Clin Sports Med 1991; 10:469-485*

20. Sahelin AC, Weiler A - All-inside Anterior cruciate ligament reconstruction using semitendinosus tendon and soft thread-ed biodegradable interference screw fixation. *Arthroscopy 1997:13:773- 779.*

21. Beynnon, Pope, Wertheiner– The effect of functional knee braces on strain on the anterior cruciate ligament in vivo. J Bone Joint Surg 1992; 74(A):1298-1312.

22. Bach, Warren – Arthrometric evaluation of knees that have a torn anterior cruciate ligament. J Bone Joint Surg 1990; 72(A):1299-1306.

23. Clancy, Ray, Zoltan - Acute tears of the anterior cruciate ligament. *J Bone Joint Surg 1988; 70(A):1483-1488*

24. FRANK, CYRIL & W. JACKSON, DOUGLAS. (1997). Current Concepts Review. The Science of Reconstruction of the Anterior Cruciate Ligament. Journal of Bone and Joint Surgery. 79A.

25. Hamid Barzegar, MohammadaliMohseni, Ali Sedighi, AbolfazlShahsavari and HossienMohammadpour, 2011. Arthroscopically-Assisted vs. Open Surgery in Repairing Anterior Cruciate Ligament Avulsion. *Pakistan Journal of Biological Sciences, 14: 496-501.*

26. Cameron SE, Wilson W, St Pierre P. A prospective, randomized comparison of open vs arthroscopically assisted ACL reconstruction. Orthopedics. 1995;18(3):249–252.

27. Spindler K.P., Kuhn J.E., Freedman K.B., Matthews C.E., Dittus R.S., Harrell F.E. Anterior cruciate ligament reconstruction autograft choice: Bone-tendon-bone versus hamstring: does it really matter? A systematic review. Am J Sports Med. 2004;32:1986–1995

28. Wagner, Michael & J Kääb, Max &Schallock, Jessica & Haas, Norbert &Weiler, Andreas. (2005). Hamstring Tendon versus Patellar Tendon Anteriro Cruciate Ligament Reconstruction using Biodegradable Interference Fit Fixation. The American journal of sports medicine. 33. 1327-36. 10.1177/0363546504273488.

29. Kostov, Hristijan&Kaftandziev, Igor &Arsovski, Oliver &Kostova, Elena &Gavrilovski, Andrej. (2014). Clinical Outcomes of Three Different Modes of Femoral Hamstring Graft Fixation in Anterior Cruciate Ligament Reconstruction. Mac. Med. Review. 2014. 53-58. 10.2478/mmr-2014-0010.

30. Ma CB, Francis K, Towers J, Irrgang J, Fu FH, Harner CH. Hamstring anterior cruciate ligament reconstruction: a comparison of bioabsorbable interference screw and endobutton-post fixation. Arthroscopy. 2004;20:122–128.

31. Colvin A, Sharma C, Parides M, Glashow J. What Is the Best Femoral Fixation of Hamstring Autografts in Anterior Cruciate Ligament Reconstruction?: A Meta-analysis. *Clinical Orthopaedics and Related Research*. 2011;469(4):1075-1081.

32. Shen C., Jiang S.D., Jiang L.S., Dai L.Y. Bioabsorbable versus metallic interference screw fixation in anterior cruciate ligament reconstruction: a meta-analysis of randomized controlled trials. Arthroscopy. 2010;26(5):705–713

33. Kousa, P., Järvinen, T.L.N., Vihavainen, M., Kannus, P., Järvinen, M. **The fixation strength of six hamstring tendon graft fixation devices in anterior cruciate ligament reconstruction. Part II: Tibial site.** *Am J Sports Med*. 2003;31:182–188.

34. Ma, Chunbong& Francis, Kimberly & Towers, Jeffrey &Irrgang, Jay & H Fu, Freddie & H Harner, Christopher. (2004). Hamstring Anterior Cruciate Ligament Reconstruction: A Comparison of Bioabsorbable Interference Screw and EndoButton-Post Fixation.

Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 20. 122-8. 10.1016

35. MusahlV, PlakseychukA,VanScyoc A, SasakiT, Debski RE, McMahon PJ, Fu FH. Varying FemoralTunnelsBetween the Anatomical Footprint and Isometric PositionsEffect on Kinematics of the Anterior Cruciate Ligament–Reconstructed Knee. AJSM(2005),33,5,712-8

36. Lim, H.-C., Yoon, Y.-C., Wang, J.-H., & Bae, J.-H. (2012). Anatomical versus Non-Anatomical Single Bundle Anterior Cruciate Ligament Reconstruction: A Cadaveric Study of Comparison of Knee Stability. *Clinics in Orthopedic Surgery*, *4*(4), 249–255.

37. Meredick, R.B., Vance, K.J., Appleby, D. et al, **Outcome of single-bundle versus double-bundle reconstructionof the anterior cruciate ligament: a meta-analysis.** *Am J Sports Med*. 2008;36:1414–1421.

38. Ha, J.-K., Lee, D.-W., & Kim, J.-G. (2016). Single-bundle versus double-bundle anterior cruciate ligament reconstruction: A comparative study with propensity score matching. *Indian Journal of Orthopaedics*, *50*(5), 505–511.

39. Mardani-Kivi, M., Madadi, F., Keyhani, S., Karimi-Mobarake, M., Hashemi-Motlagh, K., &Saheb-Ekhtiari, K. (2012). Antero-medial portal *vs.* transtibial techniques for drilling femoral tunnel in ACL reconstruction using 4-strand hamstring tendon: A cross-sectional study with 1-year follow-up. *Medical Science Monitor : International Medical Journal of Experimental and Clinical Research*, *18*(11), CR674–CR679.

40. Grant JA, Mohtadi NG. Two- to 4-year follow-up to a comparison of home versus physical therapy-supervised rehabilitation programs after anterior cruciate ligament reconstruction, Am J Sports Med , 2010, vol. 38 (pg. 1389-94)

41. Ellison AE, Berg EE. Embryology, anatomy, and function of the anterior cruciate ligament. OrthopClin North Am 1985;16:3–14.

42. Girgis FG, Marshall JL, Al Monajem ARS. The cruciate ligaments of the knee joint. Clinic Orthop 1975;106:216–231.

43. Arnoczsky SP. Anatomy of the anterior cruciate ligament. ClinOrthop 1983;172:19–25.

44. Harner CD, Baek GH, Vogrin TM, et al. Quantitative analysis of human cruciate ligament insertions. Arthroscopy 1999;15:741–749.

45. Fu FH, Bennett CH, Lattermann C, et al. Current trends in anterior cruciate ligament reconstruction. Part 1: biology and biomechanics of reconstruction. Am J Sports Med 1999;27:821–830.

46. Odensten M, Gillquist J. Functional anatomy of the anterior cruciate ligament and a rationale for reconstruction. J Bone Joint Surg Am 1985;67:257–262.

47. Petersen W, Tillmann B. Anatomy and function of the anterior cruciate ligament. Orthopade 2002;31:710–718.

48. Gabriel MT, Wong EK, Woo SL, et al. Distribution of in situ forces in the anterior cruciate ligament in response to rotatory loads. J Orthop Res 2004;22:85–89.

49. Andriacchi TP, Dyrby CO. Interactions between kinematics and loadingduring walking for the normal and ACL deficient knee. J Biomech2005;38:293–298.

50. Smith, B. A., Livesay, G. A., Woo, S. L. (1993). Biology and biomechanics of the anterior cruciate ligament. Clin Sports Med, 12(4), 637-670.

51. Woo, S. L., Gomez, M. A., Seguchi, Y., Endo, C. M., Akeson, W. H. (1983). Measurement of mechanical properties of ligament substance from a bone-ligament-bone preparation. J Orthop Res, 1(1), 22-29.

52. Fu, F. H., Bennett, C. H., Lattermann, C., Ma, C. B. (1999). Current trends in anterior cruciate ligament reconstruction. Part 1: Biology and biomechanics of reconstruction. Am J Sports Med, 27(6), 821-830.

53. Pässler H.H., Yang Y. (2012) The Past and the Future of Arthroscopy. In: Doral M. (eds) Sports Injuries. Springer, Berlin, Heidelberg.

54. Adriaensen ME, Hogan B, Al-Bulushi HI, Kavanagh EC. Double-bundle depiction of the anterior cruciate ligament at 3 Tesla. *Skeletal Radiol*. 2012 Jul. 41(7):831-4

55. Fruensgaard S, Johannsen HV. Incomplete ruptures of the anterior cruciate ligament. *J Bone Joint Surg Br*. 1989 May. 71(3):526-30.

56. Fischer SP, Fox JM, Del Pizzo W, Friedman MJ, Snyder SJ, Ferkel RD. Accuracy of diagnoses from magnetic resonance imaging of the knee. A multi-center analysis of one thousand and fourteen patients. J Bone Joint Surg Am. 1991 Jan;73(1):2–10

57. Lewis, D. W., Chan, D., Fisher, O., Lechford, R., Mintowt-Czyz, W. J., & Lewis, M. W. (2012). INCIDENCE OF MENISCAL AND CHONDRAL INJURIES AT THE TIME OF ACL RECONSTRUCTION, AND THEIR RELATIONSHIP WITH OUTCOME AT 2 YEARS. *Orthopaedic Proceedings,* 94-B(SUPP IX), 41.

58. Chaudary, D., Monga, P., Joshi, D., Easwaran, J., Bhatia, N., Singh, A. **Arthroscopic reconstruction of the anterior cruciate ligament using bone–patellar tendon–bone autograft. Experience of the first 100 cases.** *J Orth Surg*. 2005;13:147–152

59. Jomha NM, Pinczewski LA, Clingeleffer A, Otto DD. Arthroscopic reconstruction of the anterior cruciate ligament with patellar-tendon autograft and interference screw fixationThe results at seven years. J Bone Joint Surg Br. 1999;81:775–9.

60. Williams R.J., III, Hyman J., Petrigliano F., Rozental T., Wickiewicz T.L. Anterior cruciate ligament reconstruction with a four-strand hamstring tendon autograft. J Bone Joint Surg Am. 2004;86:225–232.

61. Mahiroğullari M, Kuşkucu M, Kiral A, Pehlivan O, Akmaz I, Tirmik U. Early results of reconstruction of chronic anterior cruciate ligament ruptures using four-strand hamstring tendon autograftsActaOrthopTraumatolTurc. 2005;39:224–230.

62. Kumar PK, Rambabu P, Srinivasarao K, et al. Functional outcome of arthroscopic reconstruction of anterior cruciate ligament tears. J. Evolution Med. Dent. Sci. 2016;5(10):427-432, DOI: 10.14260/jemds/2016/98

63. Veeragandham P, Raghavan V, Chattopadhyay A, Banerjee U, Kothari S. Functional outcome following arthroscopic ACL reconstruction using semitendinosus graft: a prospective observational study. Int J Res Orthop 2017;3:423-30.

64. APARAJIT, Prasad; KOICHADE, M. R.; JAIN, Nimesh. Study of Arthroscopic Reconstruction of Anterior Cruciate Ligament Injury. **International Journal of Biomedical Research**, [S.l.], v. 7, n. 6, p. 329-336, jun. 2016. ISSN 0976-9633.

65. Aglietti P, Buzzi R, Zaccherotti G, De Biase P. Patellar tendon versus doubled semitendinosus and gracilis tendons for anterior cruciate ligament reconstruction. Am J Sports Med. 1994;22:211-8.

66. Williams RJ 3rd, Laurencin CT, Warren RF, Speciale AC, Brause BD, O'Brien S. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction. Diagnosis and management. Am J Sports Med. 1997;25:261-7.

Annexure -I

2000 IKDC SUBJECTIVE KNEE EVALUATION FORM

Your Full Name_____

Today's Date: _____/_____/_____ (Day / Month / Year) Date of Injury: _____/_____/_____ (Day / Month / Year)

SYMPTOMS*:

*Grade symptoms at the highest activity level at which you think you could function without significant symptoms, even if you are not actually performing activities at this level.

1. What is the highest level of activity that you can perform without significant knee pain?

   4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
   3❑Strenuous activities like heavy physical work, skiing or tennis
   2❑Moderate activities like moderate physical work, running or jogging
   1❑Light activities like walking, housework or yard work
   0❑Unable to perform any of the above activities due to knee pain

2. During the past 4 weeks, or since your injury, how often have you had pain?

	0	1	2	3	4	5	6	7	8	9	10	
Never	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Constant

3. If you have pain, how severe is it?

	0	1	2	3	4	5	6	7	8	9	10	
No pain	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	Worst pain imaginable

4. During the past 4 weeks, or since your injury, how stiff or swollen was your knee?

   4❑Not at all
   3❑Mildly
   2❑Moderately
   1❑Very
   0❑Extremely

5. What is the highest level of activity you can perform without significant swelling in your knee?

   4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
   3❑Strenuous activities like heavy physical work, skiing or tennis
   2❑Moderate activities like moderate physical work, running or jogging
   1❑Light activities like walking, housework, or yard work
   0❑Unable to perform any of the above activities due to knee swelling

6. During the past 4 weeks, or since your injury, did your knee lock or catch?

   0❑Yes 1❑No

7. What is the highest level of activity you can perform without significant giving way in your knee?
   4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
   3❑Strenuous activities like heavy physical work, skiing or tennis
   2❑Moderate activities like moderate physical work, running or jogging
   1❑Light activities like walking, housework or yard work
   0❑Unable to perform any of the above activities due to giving way of the knee

Page 2 – 2000 IKDC SUBJECTIVE KNEE EVALUATION FORM

SPORTS ACTIVITIES:

8. What is the highest level of activity you can participate in on a regular basis?

4❑Very strenuous activities like jumping or pivoting as in basketball or soccer
3❑Strenuous activities like heavy physical work, skiing or tennis
2❑Moderate activities like moderate physical work, running or jogging
1❑Light activities like walking, housework or yard work
0❑Unable to perform any of the above activities due to knee

9. How does your knee affect your ability to:

		Not difficult at all	Minimally difficult	Moderately Difficult	Extremely difficult	Unable to do
a.	Go up stairs	4❑	3❑	2❑	1❑	0❑
b.	Go down stairs	4❑	3❑	2❑	1❑	0❑
c.	Kneel on the front of your knee	4❑	3❑	2❑	1❑	0❑
d.	Squat	4❑	3❑	2❑	1❑	0❑
e.	Sit with your knee bent	4❑	3❑	2❑	1❑	0❑
f.	Rise from a chair	4❑	3❑	2❑	1❑	0❑
g.	Run straight ahead	4❑	3❑	2❑	1❑	0❑
h.	Jump and land on your involved leg	4❑	3❑	2❑	1❑	0❑
i.	Stop and start quickly	4❑	3❑	2❑	1❑	0❑

FUNCTION:

10. How would you rate the function of your knee on a scale of 0 to 10 with 10 being normal, excellent function and 0 being the inability to perform any of your usual daily activities which may include sports?

FUNCTION PRIOR TO YOUR KNEE INJURY:

	0	1	2	3	4	5	6	7	8	9	10	
Couldn't perform daily activities	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	No limitation in daily activities

CURRENT FUNCTION OF YOUR KNEE:

	0	1	2	3	4	5	6	7	8	9	10	
Can't perform daily activities	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	No limitation in daily activities

Annexure - II

LYSHOLM KNEE SCORING SCALE

Instructions: Below are common complaints which people frequently have with their knee problems. Please check the statement which best describes your condition.

I. LIMP:
_____ I have no limp when I walk. (5)
_____ I have a slight or periodical limp when I walk. (3)
_____ I have a severe and constant limp when I walk. (0)

II. USING CANE OR CRUTCHES
_____ I do not use a cane or crutches. (5)
_____ I use a cane or crutches with some weight-bearing. (2)
_____ Putting weight on my hurt leg is impossible. (0)

III. LOCKING SENSATION IN THE KNEE
_____ I have no locking and no catching sensations in my knee. (15)
_____ I have catching sensation but no locking sensation in my knee. (10)
_____ My knee locks occasionally. (6)
_____ My knee locks frequently. (2)
_____ My knee feels locked at this moment. (0)

IV. GIVING WAY SENSATION FROM THE KNEE
____ My knee never gives way. (25)
____ My knee rarely gives way, only during athletics or other vigorous activities. (20)
____ My knee frequently gives way during athletics or other vigorous activities, in turn I am unable to participate in these activities. (15)
____ My knee occasionally gives way during daily activities. (10)
____ My knee often gives way during daily activities. (5)
____ My knee gives way every step I take. (0)

V. PAIN:
____ I have no pain in my knee. (25)
____ I have intermittent or slight pain in my knee during vigorous activities. (20)
____ I have marked pain in my knee during vigorous activities. (15)
____ I have marked pain in my knee during or after walking more than 1 mile. (10)
____ I have marked pain in my knee during or after walking less than 1 mile. (5)
____ I have constant pain in my knee. (0)

VI. SWELLING
____ I have no swelling in my knee. (10)
____ I have swelling in my knee only after vigorous activities. (6)
____ I have swelling in my knee after ordinary activities. (2)
____ I have swelling constantly in my knee. (0)

VII. CLIMBING STAIRS:
____ I have no problems climbing stairs. (10)
____ I have slight problems climbing stairs. (6)
____ I can climb stairs only one at a time. (2)
____ Climbing stairs is impossible for me. (0)

VIII. SQUATTING
____ I have no problems squatting. (5)
____ I have slight problems squatting. (4)
____ I can not squat beyond a 90 degree bend in my knee. (2)
____ Squatting is impossible because of my knee. (0)

TOTAL_____/100

INSTRUCTIONS: Please place an X on the line to indicate the amount of pain you have had in your knee(s) the past 24 hours. The scale ranges from "no pain at all" to the "worst possible pain".

RIGHT KNEE _____
no pain worst possible pain

LEFT KNEE _____
no pain worst possible pain

Annexure - III

PROFORMA

S. no:

Patient details

Patient Name :	Age :	Sex : M/ F / TG
Occupation :		IP NO :
Address :		Contact no :
Unit :	Professor :	
DOA :	DOS :	DOD :

Clinical History :

Presenting Complaints :
Side:
Knee pain:
Instability:
Swelling:
Locking:

Mode of Injury :
Fall
RTA
Sports
Others

Clinical Evaluation

Pre injury status

Ambulation :	CVS :
Obesity :	RS :
Diabetes :	CNS :
Hypertension :	Psychiatric illness :

Back ground Data

Smoker :
Alcoholic :
Drug intake :

Associated injuries

Local Examination

Effusion:
Lachman test:
Anterior drawer test:
Posterior drawer test:
McMurray test:
Varus stress test:
Valgus stress test:

Radiological Evaluation

X – ray knee AP and Lateral:

MRI knee:

GRADE:

Associated injuries:

Posterior cruciate ligament

Medial meniscus

Lateral meniscus

Medial Collateral ligament

Lateral collateral ligament

Others:

Diagnosis :

Plan :

OPERATIVE DETAILS

Date of Surgery from injury :

Anaesthesia : GA / SA / Epidural Fitness Under ASA : I / II / III / IV

Operative Technique

Approach :

Position :

Implant used for fixation of graft in
Femoral tunnel:

Tibial tunnel:

Meniscectomy:

Duration of Surgery :

Per operative findings and remarks :

Post operative :

SICU stay : Yes / NO

Units of blood transfused :

Duration of I.V Antibiotics :

Post-operative Evaluation

Knee effusion :

Surgical site infection : Swab for C & S in case of infection :

Septic arthritis:

Fever:

Neuro vascular injury :

Radiological Evaluation :

Duration of hospital stay:

Wound healing:

Follow up

2nd week

Date :

Wound healing :

Suture removal done on _____post op day

Adivce& Remarks :

Professor

6 th week

Date :

Clinical status :

Adivce& Remarks :

Professor

6 th Month

Date :

Clinical status :

Range of movement :

Laxity :

Anterior Knee pain :

Radiological evaluation :

IKDC knee score:

Lysholm knee score:

Adivce& Remarks :

Professor

One year

Date :

Clinical status :

Range of movement :

Laxity :

Anterior Knee pain :

Radiological evaluation :

IKDC knee score:

Lysholm knee score:

Adivce& Remarks :

Professor

Annexure - IV

ஒப்புதல் படிவம்

பெயர் -

பாலினம் -

முகவரி - **வயது** -

அரசு கோவை மருத்துவக் கல்லூரியில் முட நீக்கியல் துறையில், பட்டமேற்படிப்பு பயிலும் மாணவர் **மோகன் பிரசாத்.எம்** அவர்கள் மேற்கொள்ளும் "**ASSESSMENT OF FUNCTIONAL OUTCOME OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLE HAMSTRING AUTOGRAFT**" என்ற சோதனையின் செய்முறை மற்றும் அனைத்து விபரங்களையும் கேட்டுக் கொண்டதுடன், எனது அனைத்து சந்தேகங்களையும் தெளிவுப்படுத்திக் கொண்டேன் என்பதை தெரிவித்துக் கொள்கிறேன்.

நான் இந்த ஆய்வில் முழு சம்மதத்துடனும், சுய சிந்தனையுடனும் கலந்துகொள்ளசம்மதிக்கிறேன்.

இந்தஆய்வில் என்னுடைய அனைத்து விபரங்களும் பாதுகாக்கப்படுவதுடன் இதன் முடிவுகள் ஆய்விதழில் வெளியிடப்படுவதில் எனக்கு எந்த ஆட்சேபனையும் இல்லை என்பதை தெரிவித்துக் கொள்கிறேன். எந்த நேரத்திலும் இந்த ஆய்வில் இருந்து விலகிக் கொள்ள எனக்குஉரிமை உண்டு என்பதையும் அறிவேன்.

இடம்

தேதி கையொப்பம் / ரேகை

Annexure - V

MASTER CHART

S.No	Name	Age	Sex	Mode of Injury	Side of Injury	Time since Injury(months)	Meniscal Injury		Follow up(months)	Lysholm knee Score - Grade	IKDC score	
							Medial meniscus	Lateral meniscus			Pre op	Post op
1	Prakash	32	M	RTA	Right	6	Yes	No	14	100 – excellent	47.1	90.8
2	Dinesh Kumar	35	M	Fall from height	Right	4	No	No	17	93 – Good	56.3	87.4
3	Kavitha	34	F	RTA	Left	6	Yes	Yes	14	86 – good	44.8	82.8
4	Vadivel	30	M	RTA	Right	18	Yes	No	21	94 – good	65.5	92
5	Loganathan	20	M	RTA	Right	12	Yes	No	16	95 – excellent	66.7	95.4
6	Elango	27	M	Sports – cricket	Right	6	Yes	No	27	76 – fair	55.2	70.1
7	Sunder	36	M	Sports – Kabaddi	Left	2	No	No	12	88 - good	40.2	85.1
8	Nagarajan	21	M	Sports – Kabaddi	Left	48	No	No	14	100 – excellent	43.7	94.3
9	Chinnathangam	32	M	RTA	Right	1	Yes	No	22	95 – excellent	44.8	93.1
10	Aswin Kumar	26	M	Others – Kick by bull	Right	3	Yes	No	14	99 – Excellent	28.7	92
11	Balakrishnan	37	M	RTA	Right	2	Yes	No	23	80 – Fair	51.7	73.6
12	Anand Prabhu	22	M	Sports- Kabaddi	Left	5	Yes	No	22	100 – excellent	64.4	94.3
13	Balamurugan	23	M	Self-fall	Left	12	Yes	Yes	7	90 – Good	60.9	89.7
14	Franklin Joseph	33	M	RTA	Left	6	No	No	18	92 – good	62.1	95.4
15	Jayaprakash	25	M	RTA	Right	5	Yes	No	24	99 – excellent	59.8	93.1
16	Jothimani	35	F	Self-fall	Left	2	Yes	No	21	85 – good	50.6	81.6
17	Manjula	29	F	RTA	Left	8	Yes	No	24	81 – fair	40.2	85.1
18	Balakrishnan	24	M	RTA	Right	36	No	Yes	17	100 – excellent	36.8	88.5
19	Pasupathi	22	M	RTA	Right	2	Yes	Yes	15	99 - excellent	50.6	86.2
20	Senthil Kumar	40	M	RTA	Left	6	No	No	10	86 - Good	47.1	82.8